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FOREWORD

This symposium and workshop was designed to provide an opportunity for researchers and others directly involved in range economics to meet formally. Such a formal meeting had not taken place since the late 1960's at conferences sponsored by the Western Agricultural Economics Research Council (WAERC). Through the papers presented, discussions, and work sessions, a feeling for the state-of-the-art was gained. The amount of effort expended in range economic studies is at the lowest level in years and the immediate outlook for increased funding is not bright. There are, however, major problem areas that need immediate attention and considerable amounts of research effort.

Several papers were presented that are not included in these proceedings. These presentations were of a non-techical nature and the presentors did not submit documents for inclusion.

Of major interest is the consensus that a regional research coordinating committee would be desirable and that a followup meeting should be held in 1984 in connection with the Western Farm Economic Association annual meeting.

--Fred J. Wagstaff, Program Chairman

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CONTENTS

AN HISTORIC LOOK AT RANGE ECONOMICS RESEARCH

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ABSTRACT: Historic eras were designated frontier, descriptive, renaissance and public policy. Highly-trained economists appeared in the third era. After withdrawal of institutional support at the end of this era, the need for new normative research efforts generated the present momentum. Several successes and failures were noted.

INTRODUCTION

A coherent description of the historical aspects of range economics research requires some type of organization. The organization should have goals of identifying and categorizing like and unlike items by time periods. Consequently, the period being examined of about 110 years has been divided into four eras. Each period will be described in terms of the kinds of problems selected for range economics research, including a sample of those involved in the research, and a summary of the institutional units involved, kinds of publications, and economic tools most often used.

Inevitably, important individual and even group research contributions will be overlooked, partly because compilation of any history normally requires a period of years of search and analysis rather than the few weeks available to prepare this paper. Also, some bias will be apparent in the selection of topics because all of the speakers in this Range Economics Symposium have been actively involved in range economics research for periods up to and including three of the four eras to be described. Each has specialty areas. In any event, the guiding policy will be to attempt to avoid citing all of the literature dealing with particular problems and select only those considered as classics or turning points in the history of range economics research.

Major sources used in the organization and preparation of this paper were a book chapter[1] that failed to survive the editor's knife, and several bibliographies. Important bibliographies that should be in the libraries of historians are those by Renner (1938) dealing with the frontier period, an inventory of research followed by a supplement on economic development of western range resources by Cummings (1952; 1953), a selected bibliography on range resources and management by Caton (1954), and a range and ranch economics bibliography dealing with economic research in the use and development of range resources (Gray and El Saadi 1969).

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[1]Gray, James R. Las Cruces, N. Mex.: Research in range and ranch economics; chapter II manuscript; pp. 36-77, 1964.

THE FRONTIER PERIOD

Range economics research, including research dealing with the economics of the ranch firm, began about 1870. This beginning coincided with large-scale livestock migrations into the western range area from the east and south. As such, the economics research effort was as early, if not earlier, than research efforts of the other sciences having a western agricultural locale. Indeed, the one biological science most closely associated with range economics -- range management -- did not appear until after the beginning of the new century.

Land Utilization, Settlement and Public Land Administration

The earliest research efforts were concerned first with land utilization, settlement and public land administration. A second group was cost of production and the economics of ranching. The third group of problems was that involving marketing. Although a considerable number of articles were prepared both on national forest administration and range livestock associations during the frontier period, most of them were in popular trade journals or magazines. Many of these early articles were based more on casual observation and opinion rather than on systematic research procedures. The economic model used almost exclusively was the positive model and the descriptive results were prepared for non-professional audiences.

Some examples of the earliest research in land utilization, settlement, and public land administration were those of Powell (1879) in Utah and Donaldson's (1884) history of the public domain. Homesteading became a subject for considerable research, both economic and political (Sanborn 1900). Organization and operation of the Forest Service occurred at about this time and caused a considerable outpouring of articles, regulations and comment. Among the earliest were articles by Hermann (1902) and Roth (1902), a series of articles in the proceedings of the American Foresters' Congress by people such as

Potter (1905), and the first of the grazing regulations by Pinchot (1908).

The growing controversy between range users and the federal land agencies regarding land utilization received much attention from authors such as Barnes (1916) and Authier (1925), with titles such as "Both Sides in the Range Controversy." The controversy evolved to the nub -- which group, ranchers or government, were to have final control of grazing.

Costs of Production and Economics of Ranching

Among the first of the studies of the costs of producing range livestock were those by Smith (1910) in Nebraska and Morton (1914) in Colorado. A large number of these studies were released over the next decade, involving almost all of the then active researchers in range economics. Examples in the two Great Basin states were Brennan and Smith (1928) in Nevada and Esplin and others (1928) in Utah. A list of those working in the various areas (without references to their works) would include Vass of Wyoming, Potter and Jardine of Oregon, Cox and Parr of Texas, Voorhies of California, Barber of Idaho, Pickrell of Arizona, Wilcox of Kansas, Hedges of Nebraska, Walker of New Mexico, and Klemmedson and Parr and Burdick of Colorado. All of these studies were published within a five-year period, 1925-1930. For those of us with over 20 years of experience in the field, these names are almost legendary in range economics research.

Two studies deserving special mention because they were the first of their kind were two region-wide studies. The comprehensive studies dealt with ranch organization and methods of livestock production in the Northern Plains (Wilson and others 1928) and in the Southwest (Parr and others 1928).

A unique comprehensive study was made by Bray (1928) and released by the Colorado station. Bray's study was entitled "Financing the Western Cattleman." Bray cited 113 pieces of literature on the subject of financing, including a book published by Larmer (1926).

Livestock Marketing

Livestock marketing was one of the first concerns of range economics researchers in the western range area because of the isolation of the area and distances to market. Subjects studied included product standards for wool (Bond 1873), sheep (Coffey 1908), horses (Davenport 1901), and cattle (Mumford 1902). Among the miscellaneous marketing subjects studied prior to 1920 were costs and methods of transporting products, cooperative marketing, accounting systems, exports and imports, shrinkage and prices. After 1920, subjects included carcass market classes and grades (by several authors), marketing costs, and association and cooperative marketing.

Other Characteristics

Almost all of the researchers of this period were untrained in the economics discipline. Rather, those educated prior to 1900 typically had bachelor of arts or science degrees which may or may not have been in agriculture. Those after 1900 were trained in agriculture, with specializations mainly in agronomy and animal husbandry. The organizations sponsoring research during the period were mainly departments of agronomy and animal husbandry at the land grant colleges and the federal Department of Agriculture. The standard publication style was station bulletins, or farmer, technical or departmental bulletins of the federal establishment. Geographically, the various authors conducted their research near their home bases, or at the most not farther than their state boundaries, with the exceptions noted above. A significant development in analysis occurred in the closing years of the period, when authors began to analyze ranch operations to isolate factors associated with profitability. If used at all, statistical analyses beyond measures of central tendency were limited to correlation analysis. Researchers of this period soon determined that ranches were too heterogeneous to permit much confidence in results of more sophisticated statistical analyses.

THE DESCRIPTIVE PERIOD, 1930-1949

In the descriptive period research efforts seemed to indicate a concern for the history of the industry as well as the necessity of inventorying and classifying rangeland resources. Taxation and finance became important subjects, particularly during the Great Depression, as well as tenure and appraisal situations and procedures. Probably from the earlier studies, the first of the analytical research efforts dealing with management appeared during the early portions of the period. It could be theorized that, with the exception of the inventory studies appearing in the mid and late 1930's, much of the research of the 1930's and early 1940's was based on research problems and methods introduced in the late 1920's. Few marketing studies were published prior to 1946. Also, organization and cost of production studies were numerous in some states as researchers, realizing that earlier efforts covered areas that were too broad, attempted numerous studies of much smaller areas.

A noteworthy accomplishment of this period was the appearance of the first general textbooks dealing mainly with the western livestock industry.

History of Western Ranching

Tremendous changes were taking place in the range livestock industry with the closing of the public

domain in 1934, along with widespread drought, unprecedented depression, mobilization for a second world war, and the initiation of large-scale welfare programs. One such of the latter was a program to subsidize historical research. Several researchers, either nostalgically or opportunely, prepared histories of the industry. A few of them were Briggs (1934) in the north-west, Saunderson (1936) in Montana, and Towne and Wentworth (1945) of the entire western range area. Perhaps anticipating the senior researchers were numerous graduate students who chose historical subjects for their M.S. theses, starting shortly after 1900 and reaching a peak in the 1930's.

Inventories of Range Resources and Type-of-Farming Studies

Concern with the closing of the open range also resulted in many studies of the apparently shrinking land base. Surprisingly little was written about the Taylor Grazing Service that came into being during this period. The major effort in inventorying resources was in drawing lines, lines to separate the range area from intermingled farming areas, and to describe the major physical and economic resources of farms and ranches in each area. Studies were made in almost all western states, including those by Clawson and others (1936) in Utah, Hunter and others (1935) in Colorado, and Johnson and Vogel (1934) in Idaho. The inventory effort was so large that teams of researchers were usually employed to complete the effort.

With completion of the inventorying effort and the close of World War II, results were combined with historical economic studies of ranch organizations, costs and returns in areas extending over several states. The Bureau of Agricultural Economics of the U.S. Department of Agriculture took the lead in this effort and the first of the annual studies dealing with ranch costs and returns were released. The early authors were Jones and Goodsell (1946) and Hochmuth and Goodsell (1948). These studies were unique for their time because they dealt with annual ranch data usually for two or more decades.

Taxation, Finance, Tenure and Appraisal

With increased private ownership of rangelands that took place in the 1920's and the closing of the open range in the 1930's, the great depression accelerated concern about land tenure. For example, land taxes became a major ranching cost during this period, particularly during depression. Tax studies were conducted in various states, with the geographical extremes being in New Mexico (Callaway and Cockerill 1935), and Oregon and Washington (Pingree 1930). Financing became a pressing problem for many ranchers, and studies were initiated by Jordan (1936) and Pelzer (1936).

Tenure studies were being made in the types of farming areas mentioned earlier. That is, the location and the common types of farms and accompaning ownerships were being described. But emphasis was needed to determine how rangelands might best be owned. The demand was met by authors such as Renne (1936) in Montana, and Loomer and Johnson (1949) and Kelso (1947) on federal lands.

Land prices first fell in the early 1930's and began their spectacular rise in the later 1930's. Land value and appraisal studies were needed. Making them were Clawson (1938) and Roth (1948).

Analytical Studies

The growing knowledge of range and ranch economics gained in the 1920's and 1930's resulted in studies of a new kind. These were studies of factors that affected production and income on cattle and sheep ranches as a primary focus. The normative aspects of optimization were based more on intuitive knowledge and experience rather than quantitative analysis (the earliest generation of econometricians were matriculating at about this time, and the second generation being born). Notable contributions highlighting the major factors affecting production levels and costs were made by Brennan and others (1933) in Nevada, and Nelson and Korzan (1941) in South Dakota.

Livestock Marketing

Passage of the agricultural Research and Marketing Act of 1946 reserving 20 percent of Hatch research funds for marketing stimulated interest in this subject in the late 1940's. A cooperative and significant effort by a new kind of organization, a western research technical committee, permitted researchers in several states to coordinate their efforts and conduct research with common objectives in multi-state areas. Previously this had been the exclusive domain of the federal government. A study of the shifts in trade of western slaughter livestock resulted (Western Livestock Marketing Research Committee 1950).

Range Improvements

The appearance of studies specifically dealing with the economics of range improvements was a special feature of research during the period. The study by Pearce and Hull (1943) on artificial reseeding was among the first, and that by non-economists. A joint effort of the Bureau of Agricultural Economics (1949) produced a nation-wide assessment of forage values, including western range reseeding.

Other Characteristics

The research up to the end of the decade was conducted by a group of researchers with several decades of experience, but lacking formal agricultural economics training. One event occurred that established the foundations for a profound change of this old guard. A document was published by the Secretary of Agriculture (1936) that dealt with the major range problems and their solutions, including social and economic functions. The range livestock industry responded with its own view of the range situation (Mollin 1938). Enough questions were raised by both documents that the name of the game in the future was to be "hard ball" played by highly-trained economists dealing with highly complex issues.

Again publications were mostly of the bulletin type with a few journal articles, proceedings papers and textbooks. Notable among the latter were the resources book by Clawson (1950). Economic tools used again were mostly descriptive budgeting with some insight based on experience.

THE RENAISSANCE PERIOD, 1950-1969

Research in the 1950's largely fell into three broad areas of marketing, range improvements and costs and returns by type of farming areas. By the 1960's, a wide variety of problems were being investigated. Perhaps most significantly, the new generation of economists entering the field in the early 1950's was not satisfied with the positive model and instituted studies utilizing the normative model. This group was highly trained, but lacked the decades of experience accumulated by such men as Clawson, Saunderson, Potter, Kelso, Burdick, Brennan and Vass. The research generally was scaled down to one or two special problems. Of particular importance was release of the first of a series of research methods in range and ranch economics (Hopkin 1954; McCorkle and Caton 1962). Another important element during this period was the establishment of a western research technical committee specifically assigned the task of doing research in range economics, and establishment of a Farm Foundation committee involved in the use and development of range resources. The latter committee was not charged with conducting research. Rather, they were charged with suggesting research needs, developing methodologies, and exchanging information on research methods and progress in their various states or organizations. The brief history of this group has been compiled (Committee on the Economics of Range Use and Development 1969).

Livestock Marketing

A very large number of publications were released during the two decades of this period on the subject of marketing. A special federal agency (the Agricultural Marketing Service) was established to coordinate efforts and make regional marketing studies. As marketing was a very large subject during the renaissance period, it deserves a history of its own. Consequently, only a few special studies will be cited. The areas of concentration were regional and state studies of market structure, conduct and (in a few cases) performance. Special studies were concerned with imported cattle (Seltzer and Stubblefield 1960), shrinkage (Harston 1959), and margins and costs (Agricultural Marketing Service 1956).

Range Improvements

The major economic research emphasis during the renaissance period dealt initially with range improvements and eventually with range enterprise analysis. This was not a happenstance event, but resulted from a deliberate, organized decision. The Western Agricultural Economics Research Council, itself organized in 1948, formed a committee to foster research in the field of public land management on June 22, 1948 (Committee on the Economics of Range Use and Development 1969). The committee was called the Range Land Tenure Committee. Members consisted of Kelso of Montana (Chairman), Mason of Nevada, and Blanch of Utah. This committee fostered a project dealing with public land management, undertaken jointly by the Bureau of Agricultural Economics, U.S. Department of Agriculture, in California.

As a result of a report by Thomas of Utah, who was charged by the Council in 1950 to study research needs in the field of western range land and water resources, a committee proposal was developed by him in 1951. Thomas called a meeting at Logan, Utah in February 1951 to consider a program of research in the field of the economics of resource development. It was attended by about fifteen western agricultural economists. As a result of his recommendation, the Council appointed two standing committees, one of which was to deal with the economics of range resource development.

A motion was made and passed at a meeting of the Western Agricultural Economics Research Council at Logan, Utah on February 19-21, 1950 to discharge the Range Land Tenure Committee and replace it by a new committee, to be called "Committee on Development of Range Resources." According to a letter from Kelso, Vice-President of WAERC, dated April 14, 1951, which was addressed to Ackerman of the Farm Foundation, a formal application for grant of funds was made. Membership of the new committee was Kelso of Montana (Chairman), Upchurch of the Bureau of Agricultural Economics, Plath of Oregon, Blanch of Utah, and Mason of Nevada. It was indicated in the letter that the committee was not complete, with representatives yet to be named from Wyoming, Colorado and New Mexico, plus a member from the Division of Farm Management of the Bureau of Agricultural Economics. Upchurch was a representative of the Division of Land Economics. The committee appointed eventually consisted of Kelso of Montana, Broadbent of Utah,

Mason of Nevada, Pingrey of New Mexico, Plath of Oregon, and Upchurch of BAE.

The first meeting of the Committee, which was financed by the Farm Foundation, occurred on September 13-14, 1951 at Ogden, Utah. The agenda included a review of past activities (review of activities of the Range Land Tenure Committee), review of the report on the California Project, and a review of past and current research in the technologies of range land development. Other major items were proposals for research in land development, capitalization of public range land values into private land values, use and control of state-owned grazing lands, and methodology. Several participants were present representing the BAE, Forest Service, and the Bureau of Land Management.

The second meeting of the Committee occurred at Flagstaff, Arizona on July 18-19, 1952. Included on the program were discussions of range reseeding by Plath of Oregon, range improvement practices by Caton of Idaho, theoretical work in California by Upchurch of the BAE, pilot soil conservation districts by Mason of Nevada, and a review of current research needs by Baker of Montana, Hopkin of Wyoming, Burdick of Colorado, Pingrey of New Mexico, Seltzer of Arizona, and Hochmuth of the BAE in Utah. Also, research needs from the federal standpoint were reviewed by Heerwagen of the Soil Conservation Service in Albuquerque, Frandsen of the SCS in Portland, and Arnold of the Forest Service in Tucson.

The third meeting of the Committee consisted of a ten-day workshop at Logan, Utah dealing with research methods. The meeting took place from December 1-10, 1952. At this meeting, an organizational meeting took place and a draft was prepared for a new proposed regional research project, tentatively identified as RMA W-16-A, "Economics of Range Land Improvement."

Since the first meeting of the Committee, it met on the average of once a year for a total of nineteen meetings, terminating in the meeting at Tucson, Arizona on November 19-21, 1968.

Functions of the Committee were to: 1) Explore new areas of needed research in the general area of the economic use and development of resources related to range and range livestock production, 2) Explore methodological issues with respect to selected areas for research, and 3) develop bibliographies of publications dealing with use and development of range resources. Eleven proceedings issues were released.

Regional research projects generated by the Committee were Economics of Range Improvements (W-16), Economics of Range Resources Use (W-16 Revised), Economic Analysis of Range and Ranch Management Decisions on Western Livestock Ranches (W-79), and an Economic Study of the Demand for Outdoor Recreation (WM-59).

The latter project deserves special mention. The Committee and the Water Resources Committee, the latter also being a WAERC-Farm Foundation committee, independently recommended to the WAERC that a regional recreation research project be authorized. The first such project bringing order to the chaos of prior recreation research was authorized in 1966.

One interesting development during this period was a joint meeting with range scientists in Reno, Nevada in 1954. The economists present sought guidance from the range scientists on a meaningful measure of range productivity. Debate continued for three days, from October 20 through October 22. On the last day, the economists forced a vote among the range scientists, which were split into four groups, Utah, California, Texas and miscellaneous. By one vote a "majority" was reached and the animal unit measure has since been the standard unit of measurement. Feelings generated were such that this was the first and last time a region-wide group of range scientists were willing to meet with a like group of range economists.

Ranch Studies by Type-of-Farming Areas

Ranch studies by type-of-farming areas essentially were continuations of studies of organizations, costs and returns of groups of ranches in extensive areas thought to have common characteristics. Studies were conducted by the BAE and reported various statistics each year for a decade or more of "typical" or "representative" ranches (Gray and Baker 1951). Numerous studies were published in three major range areas -- Intermountain, Northern Plains and Southwest.

Analytical Studies

The renaissance period is noted for the first efforts to improve research techniques in range and ranch economics research. The eleven proceedings mentioned previously dealt largely with analytical techniques. Also, publications were released by Caton (1956) on budgeting, McCorkle (1956) on linear programming, Wallace and Judge (1958) on econometrics of the beef sector, Hopkin (1954) on optimal grazing, and a proceedings bulletin on risk and uncertainty (Great Plains Council 1955).

During the latter part of the period, the normative and predictive models were used in pricing and decision-making (Kearl 1963), estimating optimum cattle systems including range improvements (Barr and Plaxico 1961), and analyzing grazing fee impacts (Range and Ranch Management Investigations Group 1962). Economic impacts of drought decisions were initiated dealing either with drought predictions (Abel and others 1962), or adjustments to drought (Boykin 1964). The

internal rate of return equation was used extensively in range improvement investigations. A shift occurred during the period when it was decided that perhaps it was a mistake to study range improvements when the economics of the basic range livestock enterprise was imperfectly understood. Consequently, during the late years of the 1960's, the regional research committee constructed ranch budgets. During the last years of the period, ranch decision-making was a primary concern and studies were initiated utilizing Bayesian decision theory.

A wide variety of miscellaneous studies were released on the subject of state land administration (Wennergren and Roberts 1963). Incorporation received attention by Hubbard and Blanch (1961), and the first of a series of textbooks dealing with day-to-day ranch operations was published by Oppenheimer (1961). Important studies by Martin and Goss (1963) dealing with economies of scale of ranches, and by Lessley (1962) describing legal aspects of ranching, were unique.

Other Characteristics

By 1969, the inexperienced but highly-trained economists of the early 1950's had accumulated much experience and expertise on the subject of range and ranch resources, both at the state experiment station and the federal Economic Research Service levels. Part of this quality was due to individual effort and part to interactions when the group met together. A wide variety of new tools was utilized, including production economic tools, internal rate of return equations, linear programming, and Bayesian decision theory. A wide variety of media were used, with symposia and an annual compendium of papers at annual meeting taking the lead. The geographic emphasis was toward regional publications based on contributions from individual states, rather than the federal research group making investigations in two or more states.

THE ANALYTICAL AND PUBLIC POLICY PERIOD, 1970-1982

Withdrawal of regional funds and Farm Foundation support had disastrous impacts early in this period on the progress of range economics research. The communication lines were severed, particularly with termination of the regional research project. Consequently, most economists of the previous period drifted into a wide variety of other subjects and activities, mainly to assure continued financing of their research efforts. These other subjects and activities included recreation, energy and extension or administration. Increased concern about allocations of public land resources generated a revival about mid-decade with substantial resulting implications. Public policy decision-makers demanded that economics be woven into the fabric of their programs. When the response from those still in the field was underwhelming, the public agencies set about forming their own cadre of economists. These latter economists again lacked experience in the beginning, but are rapidly acquiring it in the crucible of environmental versus developmental conflicts. Meanwhile, the federal Economic Research Service underwent a series of rapid reorganizations and name changes (starting as far back as the early 1950's), the apparent goal of which was to be more responsive to national agricultural concerns and the Congress. In the process only one or two small viable groups concerned about range resources survived.

Most present-day economists are familiar with the history of range economics research for the past decade. Further, the analytical and public policy period has yet to be replaced by a new period, possibly in the 1990's. It is too early to objectively describe this period. Consequently, this section dealing with an on-going period will be abbreviated and few references will be cited.

An analysis of research in progress in 1971[2] revealed three major problem areas. They were organization and capital structure of ranching, cost reduction strategies, and benefit estimations. Summary of the five to nine subsections revealed that most attention in 1971 was being given by range economists to five areas of research: evaluation of optimum enterprise combinations, measurement of feed-forage relationships, analysis of the effects of range improvements, investigation of cost reduction and/or income increasing effects, and determination of comparative advantages of range livestock production over other uses of land. Areas receiving little or no attention were: determination of tenure combinations, identification of capital and credit restrictions in ranching, measurement of the role of management, identification of desirable capital and estate planning procedures, determination of optimal levels of input substitutions, and designing of improved data collection procedures.

A manuscript by Rafsnider and Skold[3] outlined several areas of research undertaken during the 1970's in the areas of range improvements, management and grazing systems.

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[2]Gray, James R. Las Cruces, N. Mex.: Review of research in progress, economics, 1971. A report to the Great Plains Range and Livestock Management Committee manuscript, 4 p, 1971.

[3]Rafsnider, G.T.; Skold, M.D. Fort Collins, Colo: Advances in regional and macro pasture and range economics in relation to a conceptual framework for grazed forage assessments, Rocky Mountain Forest and Range Experiment Station general technical report manuscript, 146 p, 1981.

Traditional Subjects

Wider use of computers and computerized ranch budgets led to several developments. Profitabilities of seeding rangeland or cropland to grass were investigated in several areas (Allen 1972; Cordingly and Kearl 1975). Brush control also received much attention by authors such as Murphy and Torrel (1972). A thorough analysis of problems in the sheep industry resulted in a series of publications authored by Gee and Magelby (1976). Anderson and Jemstedt (1971) evaluated the multiple economic effects of forage development and management in three major ranching areas using a case study approach. A model developed by Stevens and Godfrey (1972) specified effects on forage flows and use rates of specified investment paths in the Vail Project. Nielsen and Workman (1971) analyzed the impacts of federal grazing on state and county economics. The economics of grazing system was being investigated mainly by non-economists (Kothman 1975; Huss 1969). However, economists[4] began to take an interest in the subject mainly because of the time dimension in this kind of range decision-making.

Federal Range Policy

Advent of the environmental impact statements brought a new burst of activity, both in use of the traditional economic tools of budgeting and linear programming, but also applications of new tools to range resources and range policy. Perhaps the opening bell for participation in research dealing with public range policy was the work of consultants such as Nielsen of Utah in determining grazing fee levels as early as 1967. Since then there has been a great outpouring of benefit-cost ratios, input-output models, and linear programming results to estimate direct or indirect effects, optimum combinations of resources, and ranch budget generators. In at least one case, a special interdisciplinary organization was formed to deal specifically with public range policies that seemed to appear daily in the Federal Register. The Economic Research Service was not exempt from this activity, providing budgets for the agencies and preliminary current year budgets for the Congress (Economic Research Service 1981).

Some of the research resulting from the requirements of federal agencies to include economic dimensions to their background and decision documents will be discussed at this symposium. Certainly, the numerous environmental impact statements and socio-economic profiles compiled by economists both inside and outside of the two major land management agencies have served as training documents for the uninitiated. By themselves, these efforts have given new impetus to many of the research methodologies initiated during this and the preceding period.

Special range policies deserve mention here. The wilderness program and the resource planning act program initiated by the Forest Service have generated much economic research. The stewardship program, the range improvement program, the unintended Sagebrush Rebellion, and the grazing fee program of concern to the Bureau of Land Management have and will bring forth others. The requests for economists to evaluate these problems have led in some cases to a more careful application of economic theory to some of these federal proposals and programs.[5]

Other Analytical Studies

The requirements of the complex biological system known as "range" in combination with a complex economic system involving "profit and decision-making" required much more complex analyses than were permitted by the tools mentioned to this point. Simulation analysis, with its ability to deal with complex systems, was developed in response to this need. One of the earliest management studies was by Halter and Dean (1965) for a large California range-feedlot cattle operation. The model did not include any biological processes. Other models dealt exclusively with biological processes. One that stressed management aspects of both the biological and economic processes was the dissertation by Abdalla (1980) involving a typical cow-calf enterprise in New Mexico over a 50-year period.

Other Characteristics

All of the academic researchers in the analytical and public policy period were highly trained and often with natural resource backgrounds in traditional agriculture, forestry or range. The research economists in the federal government had similar backgrounds. Many of the economists in the land management agencies, particularly those attached to field units, had master's degrees in economics or agricultural economics, and many lacked agricultural backgrounds. The mode of publication during the period has shifted from the academic arena to a vast outpouring of

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[4] Workman, John P; Nazir, Muhammad. Logan, Utah: An economic analysis of Bureau of Land Management grazing systems in the Intermountain area, Utah State University manuscript, 22 p, 1972.

[5] Obermiller, Frederick W.; McCarl, Bruce A. Logan, Utah: In search of reason: Issues and alternatives in the federal grazing fee debate. American and Western Agricultural Economics Association annual meetings manuscript, 46 p, 1982.

government preliminary drafts and final drafts that are usually very site specific. Meanwhile, conference proceedings and symposia papers abound. Reliance on primary data, studies which are very narrowly site specific, and tools which have been tested and retested together have not encouraged widespread publication of refereed journal articles, a publication media which has never been particularly popular in range economics research. The geographical emphasis has remained in the western range area.

CONCLUSIONS

Areas receiving most emphasis over the four time periods identified in this paper have been ranch budget studies and studies of costs of range improvements, livestock marketing, and in later years, public range resource allocation and policy studies. Areas receiving the least emphasis have been measuring the roles of management in range resource administration and livestock production, capital budgeting, research methodology and enterprise analysis. By and large, research efforts have been successful both when measured by the continuing level of demand for economic research results as well as the respect this sub-discipline has gained among ranchers, range scientists and public land administrators.

A notable failure has been the unfavorable attitude of mistrust with which range economists are regarded by that portion of the public concerned about land and environmental relationships. Another has been the failure to exploit a closer cooperative working relationship in many states and federal agencies between range scientists and range economists. Lastly, we have still the task of successfully persuading the range livestock industry as well as many range resource managers that success or failure lies as much in the business arena as in the strictly biological one.

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RANGE ECONOMICS - A NATIONAL PERSPECTIVE

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ABSTRACT: Major range economic problems are: achieving economic efficiency; maintaining productivity; and, providing access to public lands consistent with society's goals. The current demand for, and supply of, forage lands are presented to illustrate the need for a balanced research program between range supplies and livestock demands. Several researchable topics are presented, concluding with a suggested systems approach.

INTRODUCTION

Range and pastureland, including forest land available for grazing, is a major national resource. About two-fifths of the land area of the United States is devoted to these uses. As with all major resources of this kind, there is a national interest and a national perspective. There is strong interest at the Federal level concerning policies and programs relating to range and pasturelands, including research (Public Law 95-306).

We welcome this opportunity to share with you our interpretations of a national perspective regarding the Nation's pasture and range resources. Throughout the paper we use the term national interest and national perspective; by this we mean society's overall interest in how pasture and range resources are used, including who benefits and who gains from their use, and who bears the cost.

Our plan in this statement is to cover three areas: (1) a summary statement on the range economic problems and issues viewed nationally; (2) an assessment of the current situation and outlook regarding forage for livestock grazing; and (3) a national perspective for range economics research.

RANGE ECONOMIC PROBLEMS AND ISSUES

About 835 million acres of the Nation's land base is devoted to livestock grazing (table 1). Cropland pasture makes up about 9 percent of this acreage and is located in the Great Plains and Eastern regions of the United States. Grassland pasture, range, and the forest land grazed are located primarily in the Great Plains and Western regions, although about 90 million acres of pasture land and grazed forest land exist in the Eastern States (Forest Service report; Frey). Over 80 percent of the land area devoted to pasture and range use is in the 17 Western States; therefore, matters relating to pasture and range use, to a large extent, have a regional focus.

The Federal Government owns and administers about 60 percent of the rangeland in the 11 Western States--273 million acres on which grazing is allowed. Most of the Federal land is seasonally grazed, and much has a low carrying capacity. Thus, public lands account for only about 12 percent of the forage utilized in the 11 Western States and only 3 percent nationally (Public Land Law Review Commission report). The contribution of the public range as an input to the livestock sector nationally is relatively small, yet grazing privileges associated with public lands are critical to the health of the Western range livestock industry. The Western range is a major source of feeder cattle for Western and mid-Western feedlots. Given the high level of public ownership, Federal policies and programs have significant economic impacts.

The regional distribution of the pasture and range resource, the variability in carrying capacity and the multiple interest in the publicly owned land creates several important economic and institutional problems relating to pasture and rangeland use. The following summary is intended to provide a national view concerning these problems and issues.

Efficient Use of Pasture and Range Resources

From society's standpoint, pasture and range resources in both private and public ownership should be used efficiently. This implies utilization of pasture and range resources consistent with their economic productivity and their comparative advantage in use with other regions. A national issue concerns whether the livestock sector is making full economic use of existing forage resources and forage resource potentials across the country. Certain portions of tilled land may be better used in forage production, for instance, and may be a more efficient source of forage. The trend toward conservation tillage may influence the availability of forages and crop residues for livestock; these plant materials may have a more efficient use in protecting the soil. On Western rangeland, where other economic uses are minimal, the efficiency question relates primarily to management and investment decisions to increase the economic productivity of range. Finally, on publicly owned rangeland, efficient use of the

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Table 1.--Major uses of land, 48 States[1]

Land use	1950	1960	1978
		Mil. acres	
Cropland, excluding cropland pasture	409	392	395
Cropland pasture	69	65	76
Total cropland	478	457	471
Grassland, including cropland pasture	700	698	663
Cropland pasture	-69	-65	-76
Total permanent grassland	631	633	587
Unclassified land in farms	45	45	36
Commercial forest land	484	501	[2] 470
Recreation	33	37	48
Urban	16	25	3/
Transportation	24	25	26
Wildlife refuges	9	9	18
Other land[4]	184	170	[2] 241
Total land area	1,904	1,902	1,897

[1]Source--See reference number 5.
[2]An estimated 172 million acres of both commercial and non-commercial forest land is grazed.
[3]Included in other land. A measurement of urban area comparable to that for 1970 probably would total about 45 million acres.
[4]Includes non-commercial forest land.

resource is influenced by the way the forage is priced to the user. As with all factors of production, water being a prime example, underpricing will result in overutilization--perhaps to the long-run detriment of the resource. Currently, the Congressional Budget Office is considering the option of a competitive bid process for public range to increase revenues and reduce the Federal deficit (Report to the Senate and House Committees on the Budget). Adjustments by the private and public sectors to make more efficient use of the pasture and range resource could influence the regional distribution of livestock production and pasture and range utilization.

Conservation of Pasture and Rangeland

Pasture and rangeland conservation has several dimensions. A primary concern has been the declining productivity of rangeland, an issue stemming from overuse. From an economic standpoint, arguments can be made that public grazing fees are below market values, and thereby encourage increased stocking rates that degrade range conditions. Stocking rates can be reduced, investments in range improvements can be made, grazing can be priced more in line with market values--all of which have bearing on the long-term productivity and the economics of rangeland use. In some instances, rangelands may be incapable of producing economic output on a sustained basis. In other words, any economic use may result in long-term degradation.

Another dimension of the pasture/range conservation issue concerns grassland conversion to cropland. Historically, grassland conversion on fragile lands has been a problem throughout the country, especially in the Western Great Plains. In the late 1930's after the dustbowl, highly erosive cropland was purchased by the Federal Government and placed in the national grassland program (Wooten). These lands are now administered by the Forest Service. After World War II, the Great Plains conservation program came into existence to also help shift cropland to grassland uses. This program was designed to provide technical and financial assistance on practices and management strategies to shift cropland into close-seeded vegetative cover (Kasal and Back). These programs still exist. Yet, grasslands continue to be converted to cropland, some through irrigation, but some simply go into dryland farming where the operator gambles on an occasional good crop year and high commodity prices.

From society's perspective, the Nation's long-term interest is best served if these lands are used in accordance with their production potential. As implied above, this may mean no use in the case of fragile range ecosystems, may require investments in range improvements or may result in shifts of marginal cropland to grassland uses. All of these adjustments imply economic impacts on the farmer and rancher. Further, many of the adjustments will not take place without technical assistance and perhaps financial support from the public sector.

Access to Rangeland

The access question relates primarily to the public range and who receives the right to use and benefit from its use. The range ecosystem provides many outputs. Domestic livestock grazing

is the primary economic use but wildlife, recreation and related uses have equally valid claims on the resource. While these uses are not wholly incompatible, issues exist on how the multiple demands are accommodated. One approach is to manage the resource to serve a dominant use such as livestock grazing while other uses become secondary (Public Land Law Review Commission). Another is to accommodate each purpose in accord with its value in use. Regardless of approach, economic trade-offs and opportunity costs play a significant role in these decisions.

Another facet of the access issue concerns not only who uses the range resource but what tenure the user enjoys. Control over use can involve ownership in fee simple, easements, and leasing. Leasing of public land often involves long-term arrangements. Some arrangements are considered to be in perpetuity, thereby inferring near-ownership characteristics upon the leasee. Institutional arrangements influence not only who benefits, but also who makes decisions concerning the use, conservation, and development of the range resource. The so-called "Sagebrush Rebellion" is an example of the access issue. The desire of the proponents is to shift the ownership and control of certain public lands in order to influence their use and achieve a different distribution of benefits from use.

From society's viewpoint the tenure arrangements that identify who benefits from the use of the range are important in tracing the equity and income distribution aspects of public range use. From an equity standpoint, using Jeffersonian principles, the social interest generally is best served if benefits are broadly distributed, and costs and benefits are guided by market forces to the extent possible. One can question if these principles are fully subscribed in current range resource use patterns and investment decisions.

To summarize, range economic problems, when viewed from a national perspective, have several facets: economic efficiency; maintenance of productivity; and, access by users that is consistent with society's goals. In our view these are important factors to be considered in future deliberation about range policies and programs; further, they imply a large array of issues needing economic research.

CURRENT SUPPLY OF AND DEMAND FOR PASTURE AND RANGE

The current situation concerning the supply of, and demand for, forages regionally and nationally serves as an important backdrop in identifying pasture and range economic needs. In this section, only the supply of, and demand for, domestic livestock grazing are considered.

National Forage Supply

In considering forage supplies, three categories of forage-producing land are considered--cropland pasture, permanent pasture and rangeland, and forest land used for livestock grazing (table 2).

As indicated earlier, most of the cropland pasture is located in the Eastern States, where cropping is more often an alternative; on the other hand, most of our permanent grasslands and ranges are farther west. In total, the 11 Western States contain a little over 50 percent of the forage land available, while another fourth is in the Northern and Southern Plains. Only 16 percent of the forage base acreage (mostly cropland pasture) is located in the 31 States east of the Missouri.

Most cropland is, essentially, all private ownership. However, the degree of public ownership of other land varies by region (table 3). In the 11 Western States, both permanent pasture and rangeland and grazed forest land are about even in degree of public ownership--just under 60 percent. The extent of public ownership is considerably less than this level in the Plains States; the national grasslands located in the four northern Plains States may give rise to the somewhat higher figure for permanent pasture and rangeland. Only the national forests in the East (mainly in the Southern coastal plains) constitute the small amount of public grazing in that region.

The total amount of land devoted to forage production has declined moderately since 1950. Even with this relatively fixed land base, forage supplies do vary from year to year. In most instances, the amount of precipitation available determines the short-term yield of forage. Cultural and management practices can, of course, enhance a more efficient use of the forage available, and may increase forage supplies. The moderate decline in pasture and rangeland since 1970 is associated with the increase in land cropped in response to rising export demands. To the extent this trend continues, forage supplies could diminish. On the other hand, continued crop surpluses, as we are now experiencing, could lead to even larger supplies of forage. Finally, our national land policy, particularly for the publicly-owned lands, affects the amount of forage that can actually be harvested by livestock from that acreage.

Currently, our pasture and rangeland produce forage for over 115 million head of cattle, plus 12 million stock sheep and their offspring. Range specialists estimate that grazing capacity could be increased by one-third through better management practices (Landsberg).

Demand for Forage and Range

Ruminants, be they beef cattle, dairy cattle, or sheep, are the major users of forage. On a national basis, beef cattle derive about 96 percent of their nutrition from forages, including harvested hay crops. This excludes cattle on feed. Sheep required about the same percentage of forage 15 to 20 years ago; last year, the forage base provided just over 90 percent of the nutrients for the stock sheep population. Dairy cattle nutrition has been trending more toward concentrates; dairy cattle relied on forage for 73 percent of their nutrients in 1965, but only 62 percent in 1981. We mention dairy cattle because dairying is becoming a growing enterprise in the West, particularly the Southwest. One of the major points that we wish to stress in this paper is the unique demand for

Table 2.--Forage land by region, 1978[1]

	11 Western States		2 So. Plains States		4 N. Plains States		31 Eastern States	
	Acres (mil.)	%	Acres (mil.)	%	Acres (mil.)	%	Acres (mil.)	%
Cropland pasture	8	11	16	21	10	13	42	55
Permanent pasture and range	359	61	112	19	73	12	43	7
Forest land, grazed	101	59	21	12	2	1	48	28
Total	468	56	149	18	85	10	133	16

[1]Source--see Wooten.

Table 3.--Extent of public ownership of forage base[1,2]

	11 Western States	2 So. Plains States	4 N. Plains States	31 Eastern States
	%	%	%	%
Cropland pasture	3/	3/	3/	3/
Permanent pasture and range	59	4	15	3/
Forest land, grazed	58	5	3/	6
Total	58	4	13	2

[1]Approximations based on reports and records of public agencies.
[2]Includes Indian Trust lands.
[3]Essentially 100 percent is private land.

Table 4.--Regional beef cow distribution[1]

	11 Western States		2 So. Plains States		4 N. Plains States		31 Eastern States		48 States Total
	Head (mil.)	%	Head (mil.)	%	Head (mil.)	%	Head (mil.)	%	Head (mil.)
1970	7.4	20	7.6	21	6.0	17	15.6	42	36.6
1975	8.3	18	9.6	21	7.8	17	19.9	44	45.6
1980	7.0	19	7.7	21	6.1	17	16.2	43	37.0
1982	7.7	20	8.3	21	6.5	17	16.8	42	39.3

[1]Source: Livestock and Meat Statistics, Stat. Bul. 522 and Supplements, ERS, USDA.

range and pasture grazing from our livestock population, and how that population can vary.

The carrying capacity of Western ranges is much lower than on eastern pastures. There has also been considerable feeling that the beef cattle population shifted to the Southeast during the sixties and seventies. The absolute numbers of beef cattle in the Southeast did increase during that time; in fact, the cattle population increased across the country. However, the regional distribution of beef cows, which reflects the distribution of the entire beef cattle herd, has not changed much over the past 12 years. Since 1970, the 11 Western States have contained approximately 20 percent of the Nation's beef cows (table 4). Another 38 percent has been held in the Plains States; the southern Plains plus the southern half of the northern Plains can almost be termed the "cow-belt" of the Nation. Finally, just over two-fifths of the cow herd is in the Eastern States which, of course, involves the expansion in the Southeast.

The distribution of stock sheep leans heavily toward the 11 Western States; now, 50 percent of all stock sheep are in this region (table 5). Another third of stock sheep is located in the Plains States. The distribution of stock sheep has trended away from the Eastern States and seems to be more concentrated in the areas west of the Missouri.

The location of both cattle and sheep appears to have been rather stable over time. The absolute levels of the beef cow population have varied over the production cycle in all regions; but there has been less variation in the cow herd in the West than in the East.

Livestock demand for range and pasture has varied with the net returns from livestock production. Several cost and returns studies have been advanced in recent years that show lower costs in the Range States than farther east, particularly in comparison with the Eastern States, where substantial fertilization is required (Van Arsdall). Another area that has not been addressed is the comparative advantage that livestock producers probably enjoy in the West compared with the eastern region.

Obviously, the overall demand for beef, lamb, and all meat affects the size of the Nation's cattle and sheep population. Currently, we may be in a state of transition and data are not yet available to indicate whether meat demand is increasing, stable, or decreasing. If demand rebounds after this recession as incomes increase, then pressure for grazing an expanding herd could be put on all regions. But if consumer tastes turn toward other foods, overall grazing demand will decrease. However, if the West enjoys a comparative advantage in beef production (mainly due to limited alternative uses), then most of the adjustment may be expected in other regions.

NATIONAL PERSPECTIVE FOR RANGE ECONOMICS RESEARCH[1]

The preceding discussion of range problems and issues and the situation and outlook discussion set the stage for identifying economic research needs. We will not attempt to cover a complete research agenda; instead we will focus on certain priority areas of economic research we feel would have high pay-off when looking at pasture and range as a national resource. The priority areas cover range demand, range supply, range forage pricing, and national modeling work which incorporates the supply and demand information in analytic systems to examine national pasture and range issues discussed earlier.

In 1980, staff in the Natural Resource Economics Division of ERS conducted a telephone survey of university and government offices in the Western States, including Texas, to determine the amount of range economics work underway. The survey revealed that less than 15 scientist-years of work were devoted to ranch management and range resource economics research. Federal agencies listed 3 scientist-years of effort. Much of this work is directed to ranch management problems, therefore the amount of work specifically directed to

[1]The economics research needs section of this paper draws on ideas developed in a range economics research needs statement prepared in 1980 for internal USDA review entitled, "Economic Analysis of Pasture and Range Resource Use" by Joe Barse, Mel Skold, Giles Rafsnider, and Mel Cotner.

Table 5.--Regional stock sheep distribution[1]

	11 Western States		2 So. Plains States		4 N. Plains States		31 Eastern States		48 States Total
	Head (mil.)	%	Head (mil.)	%	Head (mil.)	%	Head (mil.)	%	Head (mil.)
1970	8.4	48	3.5	20	1.8	10	3.7	22	17.4
1975	6.0	48	2.6	21	1.3	11	2.5	20	12.4
1980	5.6	50	2.3	21	1.2	11	1.9	18	11.0
1982	5.7	50	2.4	21	1.2	11	2.3	18	11.6

[1]Source: Livestock and Meat Statistics, Stat. Bul. 522 and Supplements, ERS, USDA.

questions outlined here is relatively small. The Department has considered expanding its range economics work but in an era of tight budgets and competing priorities, range economics research initiatives have rated low.

Research on Range Supply

o What is the aggregate supply curve for the western range? Is it completely inelastic with weather being the principal shifter, or are other variables involved giving it a limited slope?

o What are the costs and benefits associated with cultural and management practices; and what level of investment can be justified for range improvement practices? Too often, many recommendations are made on the basis of physical efficiencies involved, without considering the economic efficiencies which may or may not be gained.

o What is the carrying capacity in economic terms of selected pasture and range resources? Do decreased stocking rates increase overall forage productivity? Is there a change in costs as stocking rates and intensity of use change? Changes in management practices may be warranted at various stages of the cattle cycle. Oregon State has done some recent work on this (Nordbloom).

o How does substitution of harvested and grazed forages affect livestock production costs? This is also associated with the stocking rate question.

o How do price support programs and crop profits affect the shift of grasslands to cropland through irrigation development?

Research on Demand for Range

Since pasture and rangeland are relatively fixed, considerably more effort should be spent in looking at the demand for the forage it produces. In 1980, the Forest Service projected a 35-percent increase in the demand for range grazing by the year 2000, and a 41-percent increase by the year 2030. Questions now are:

o What is the current livestock population on the range, and how many are expected in the future? This centers, first, on estimation of livestock numbers that will be grazed. National and regional projections as they deal with profitability over the production cycle is one area of interest to livestock and range economists. Coupled with this are studies of costs and returns on individual ranges. While USDA prepares national and regional estimates of costs and returns from livestock production, we think that research on range demands could be better accomplished through more localized adaptations of such studies. In recent years, the Forest Service has contracted with ERS for linear programming analyses of individual range resource situations to determine the marginal values of additional forage (Gee).

o Will the overall demand for meat including beef and lamb increase, decline or remain near current levels?

o Does the Western range enjoy a comparative and/or absolute advantage over other regions for livestock production? ERS regional costs and returns budgets for beef cattle (Van Arsdall) indicate that a comparative advantage and, probably, an absolute advantage exist, but this should be documented. If so, the demand for grazing should remain high, even if the overall demand for meat decreases, as may be the case.

o Can range livestock be marketed more efficiently, thereby increasing producer returns? Any improvement in marketing practices should increase the demand for western range grazing.

Range Pricing

The grazing fee issue has been of paramount importance in the West since almost the turn of the century. Currently, work is being undertaken to advise the appropriate Secretaries of Interior and Agriculture and the Congress of what grazing fees should be after 1985 (Public Law 95-514).

o What are the variables that affect the value of range for grazing--a major factor that perhaps should influence rental rates?

o What is the pricing process for private range? How does the "price-discovery" mechanism operate?

o How should public range be priced?

Some work needs to be theoretical in nature, and then that theory put into practice to develop workable relationships. Also, the impact of various pricing levels and policies needs to be assessed, both in terms of equity to the user and owner, and in terms of the effect on livestock production.

Systems Modeling

Pasture and range forage supply and demand relationships need to be integrated into a national analytic capability to assist in the evaluation of regional comparative and absolute advantage in producing forage for livestock grazing. This capability would help identify economic efficient grazing strategies, particularly if such analyses could be matched with similar livestock and feedgrain models. Models containing range forage supply and demand relationships also would be useful in measuring the trade-off and complementary relationships between the economic and environmental uses of the pasture and rangeland resource.

The Department has new resource management and conservation program appraisal and planning authorities (Public Laws 94-588, 95-102, 95-306) which require improved information on resource issues. The economic information on pasture and range resources, both on public and private lands, is important to the assessment and planning activities required by these Acts. The needed economic research, in particular the systems modeling work outlined above, would be highly useful to those with responsibility to carry out the provision of these Acts.

SUMMARY

In this short period of time, we have tried to help set the stage for this symposium, giving a notion of the importance of the range and pasture resource and, then, assessing both the current supply and demand situations with a comment on some of the major determinants of the supply of forage and the demands for forage. We would like to reiterate that more attention needs to be given to the development of a balanced program of pasture and range economic research that emphasizes the demand for, as well as the supply of, forage. Further national studies are suggested to examine the linkage of forage supplies, non-livestock demands, and the livestock sector.

Finally, we have attempted to raise several researchable issues for your consideration in discussing economic research needs. Work on range supplies should involve both our land resource economists and those working in livestock supply. Demand research should focus both in terms of projections, in terms of models, and work in pricing efficiency. We hope this will be beneficial for your deliberations of the next few days in outlining an appropriate program of range economic research.

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MEAT - AN END PRODUCT FROM RANGELAND

CURRENT PRODUCTION AND CONSUMPTION SITUATION AND IMPLICATIONS*

W. Gordon Kearl and Patricia D. Hoye**

The purposes of this paper are:

1. to present some data on range livestock and make some inferences about production from the rangeland-harvested forage complex of 17 western and plains states;

2. to discuss meat consumption trends and present situation, nationally; and,

3. attempt to draw some inferences about directions for research.

In the history of range economics research the W-16 Project related to range improvement stands out as a case of placing the cart before the horse. When that project was undertaken sound studies of economics of ranching were not available to use as base or benchmark situations for the range improvements research. It is difficult to think of range research except in the context of the entire complex of livestock, range and harvested forages, though some lands can be called range and only used for wildlife.

This paper is based on two assumptions: (1) the question of range research needs for the next 20 years, or so is being addressed at this conference; and, (2) the concern is about all rangelands, not just the Public Lands.

LIVESTOCK INVENTORIES AND PRODUCTION

Cattle Inventories

Cattle inventory numbers of the 17 western and great plains states are summarized in Table 1 and Appendix Table 1 for states and regions as follows:

Pacific	Rocky Mountain		Great Plains	
Calif.	Ariz.	Nev.	Kansas	Okla.
Ore.	Colo.	N. Mex.	Neb.	S. Dak.
Wash.	Idaho	Utah	N. Dak.	Texas
	Mont.	Wyo.		

The dairy cows and replacement heifers are nearly equal to corresponding classes of beef cattle breeding stock in California. The dairy component is about 56% of the beef breeding stock component in Washington, between 20% and 30% for Arizona, Idaho and Utah, 16% for Oregon, 5-10% for nine other states and only about 2% in Montana and Wyoming. If other components of the cattle inventory are considered, the proportion which is dairy is further diminished. The contribution to beef production from the dairy component consists of cull cows and dairy calves grown out for beef. The latter might be considered to have left the dairy sector and entered the beef component when the decision was made to grow them out.

Dairy cattle consume a large amount of feed. However, given the high use of concentrates for dairy cattle, total roughage consumption per cow is probably less than for beef cattle.

Percentage calf crops born calculated for cows that have calved or cows plus replacements are as follows:

Region	Calf crop as a percent of: Cows that have calved	Cows plus replacements
Pacific	89.8	70.7
Rocky Mountain	92.6	77.5
Great Plains	90.5	77.8
17 States	90.9	76.8
United States	90.5	74.7

Calf crops born are only about 90% of cows and heifers that have calved or about 77% of cows plus replacements. The effect of the dairy component can be seen in the pacific region. The true percentage calf crop born lies somewhere between the extremes and perhaps about mid-way, or around 84 to 86% as an "honest percentage" calf crop born, considering only cows and replacements actually expected to calve.

Although data are not included, death losses of calves are in the 6 to 10% range, reducing the honest percentage calf crop weaned to something less than 80%.

Research directed toward the improvement of reproductive efficiency is a significant need and that aspect of range research should not be overlooked. Three specific aspects include research in development and use of flushing pastures, range nutrition for the last trimester of pregnancy, and the effects, either positive or negative, of grazing systems and grazing management techniques on reproductive performance.

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About 23 million calves are born in these 17 states. Allowing for death loss and use for replacements, the input to beef production probably amounts to about 17 million weaned calves and 3 million cull cows. Most of those represent production from a very significant input from rangelands and pastures. The use of rangelands and pastures for growth after weaning is indicated by the calves under 500 lbs. and steers and other heifers over 500 lbs., about 40% of them not in feedlots.

Production of Cattle and Calves

Production and value of production of cattle and calves in the western and plains states are summarized in Table 2. Production and value of production, unlike cash receipts or value of marketings, takes into consideration and adjusts for effects of inventory changes and resale of purchased animals. Averages for 1972-80, which includes portions of both sides of the cycle, are

Table 1. Cattle inventory numbers in the western and great plains states, 1972-81 averages, January 1. (1,000 head)

Item	Regions: Pacific	Rocky Mountain	Great Plains	Region Totals	All U.S.
Dairy cattle					
1/ Milk Cows	1,108	454	1,011	2,573	11,132
2/ Replacements	421	189	291	901	3,990
Sub-total	1,529	643	1,302	3,474	15,122
Beef cattle					
1/ Cows	2,004	5,517	15,224	22,745	40,535
2/ Replacements	421	973	2,349	3,743	6,874
Sub-total	2,425	6,490	17,573	26,488	47,409
3/ Other heifers	329	924	2,941	4,194	7,141
3/ Steers	1,485	2,032	6,451	9,968	16,566
4/ Calves	1,817	3,571	11,177	16,565	31,456
Bulls	147	336	897	1,380	2,596
Total beef cattle	6,203	13,353	39,039	58,595	105,167
All cattle and calves	7,732	13,996	40,341	62,069	120,290
Calves born	2,796	5,531	14,698	23,025	46,735
Cattle Fattening					
5/ Cattle on feed Jan. 1	1,144	2,036	5,372	8,552	12,826
Fed cattle marketed	2,199	3,790	11,943	17,932	24,242

Sources: "Livestock and Meat Statistics." Economic Research Service/Statistical Reporting Service/ Agricultural Marketing Service Statistical Bulletin No. 522, U.S. Department of Agriculture and Annual Supplements.

"Cattle: Final Estimates for 1976-79." Economics and Statistics Services. Statistical Bulletin No. 655, U.S. Department of Agriculture.

"Cattle." Crop Reporting Board, Economics and Statistics Service, U.S. Department of Agriculture. January 1981 and 1982.

1/ Cows that have calved.
2/ Replacement heifers over 500 lb.
3/ Other heifers or steers over 500 lb.
4/ Calves under 500 lb.
5/ Included in categories above, also.

Table 2. Average production and value of production of cattle and calves, western and great plains states, 1972-1980.

Region	Production (Millions) Amount	Production (Millions) Value	AUM Equivalent	Production per AUM Amount	Production per AUM Value
	(lb)	(dollars)	(thousands)	(lb)	(dollars)
Pacific	2,718	1,195	92,784	29.29	12.88
Rocky Mountain	5,551	2,554	167,952	33.05	15.21
Great Plains	15,002	6,791	484,092	30.99	14.03
17 States	23,271	10,540	744,828	31.24	14.15
U.S.	40,754	17,645	1,443,480	28.23	12.22

not greatly different from a short term average for more recent years or of the current levels. Production for these 17 states amounted to 23.3 billion lb., or about 100 lb. of liveweight produced per capita of the national population.

Prices, even at current seemingly depressed levels, are 33% to 40% above average prices for 1972-80. That has a proportionate effect on value of production, which at present is probably 33% to 40% greater than averages shown.

The importance of the industry in these 17 western and plains states can be judged by its $10.5 billion in average value of production through 1972-80 and probably $14 to $15 billion in 1982.

Animal-unit-month (AUM) equivalents, production and value of production per AUM equivalent are also summarized in Table 2, with detail shown in Appendix Table 2. For this purpose AUM equivalents were calculated by multiplying all cattle and calves shown in Table 1 by the number 12. That is analogous to use of a coefficient of 1.0 for all animals over six months of age. There is a limited amount of fall calving in these states, but most animals in the January 1 inventories, including calves under 500 lb., are over six months of age. Also, most remain in the inventory for 12 months or if removed they are replaced by the next crop moving up.

The inventory of cattle in feedlots was counted only once for calculating AUM's. Given high feed use, a higher coefficient may be appropriate, but for much less than 12 months for a particular group. Turnover through the feedlots is indicated by the ratio of cattle marketed to cattle on feed in principal feeding states. If an allowance is made for that, use of 1.0 coefficient for the January cattle on feed inventory is quite reasonable.

Obviously there are simplifications in calculation of AUM's. Use of a different and perhaps more accurate method gave AUM equivalents for cattle in Wyoming at 5.7% less than use of this simple method (Kearl 1980. Comparable results might be found in other states with small dairy or feedlot industries. Where those industries are more important the comparison between the simple or more complex methods may be worse, or quite possibly better than for Wyoming.

Given qualifications above, liveweight production per AUM equivalent is in the range of 25 to 35 lbs and mostly within 30 plus or minus 3 lbs. Noticeable exceptions are Arizona and Colorado where feedlot industries are larger than in other states, relative to the breeding herds.

Value of production per AUM equivalent is mostly within $11 to $16, with the same notable exceptions mentioned above. At 1982 prices, value or production could easily be 33 to 40% higher than shown. Production includes gain on yearlings held and some portion of production from cow sales. Montana, Nevada and Wyoming are three states with minimal dairy and feedlot effects. They have weighted average production and value of production as follows:

Montana, Nevada and Wyoming

Basis	Production (lb)	Value of Production ($)
Per AUM	27.48	$ 12.49
Per AU (AUM x 12)	329.76	149.88
Per cow and replacement	535.94	241.73
Per cow only	634.41	286.14

For comparison, taking 20 lb of hay per day or 600 lb per month as an AUM equivalent, the 1972-80 average October price of hay in Wyoming was $14.81 per AUM equivalent, which is $1.71 higher than the value of production (Appendix Table 2). Considering barley at 75% total digestible nutrients (TDN) and assuming 300 lbs TDN as an AUM equivalent then 400 lb of barley would be an AUM equivalent and cost $17.12 at 1972-80 average October prices in Wyoming. Relationships in other states and with other forms of supplemental feeds would likely be similar.

Obviously, if supplemental feed costs exceed a pro-rated value of production ignoring all other costs during the supplementation period then it will be necessary to have other times of the year when all costs are far below pro-rated value of production. That is the important role of rangelands.

It is difficult to specify the portion of production which comes from pastures or rangelands even for states such as Montana, Nevada and Wyoming where production from dairy or feedlots is negligible. Obviously, most of the animal gains occur on pastures and rangelands during periods of active grass growth. However, within any particular area and technology, growing forage and dry forages, whether hay or winter ranges and other supplemental feeds, tend to be used in relatively fixed proportions. It is difficult to differentiate among forage or seasonal range types and attribute different production to different resources when each seasonal forage resource is required in order to have any output from the breeding herd stage of production.

Many of the seasonal feed resources are substitutable or interchangeable in one direction at least. Spring, summer and fall range resources are often interchangeable, and even interchangeable with winter ranges. Obviously, high elevation ranges in national forests cannot be substituted for spring, fall or winter forage supplies. However, one winter forage, hay, can be substituted for summer forage by keeping livestock in drylot. For that reason, one might be suspicious of models that attribute to any range type or seasonal use a marginal value productivity per AUM far above the price of hay per AUM equivalent. When that happens, as it sometimes has, perhaps the model has not allowed for transformation from one to another seasonal feed, or for purchase of hay.

Sheep, Lambs and Wool

Inventories of sheep and lambs are summarized in Appendix Table 3. Unlike the cattle numbers cycle, sheep numbers have been declining and the 1972-81 averages are considerably above current levels.

AUM equivalents for sheep were calculated using a coefficient of .2 per sheep month or 2.4 AUM's for stock sheep and .2 for 2.5 months or .5 AUM for sheep and lambs on feed. There are far less sheep than cattle in the region, with much smaller requirements. Consequently, the total AUM equivalent requirement is only about 24.7 million for sheep, compared with 745 million for cattle.

Total liveweight production for the 17 states amounts to about 620 million lbs of lambs and sheep, 101 million lb of wool and about $330 million in combined value of production (Appendix Table 3). Value of production does not include government support payments for wool production.

Value of production of lambs and wool per AUM equivalent are about the same as previously indicated for cattle (Appendix Table 4).

Value of Production or Value Added

Kunz and Purcell have made studies estimating value of production and value added by production of various agricultural commodities in 1979, including three studies with information pertinent to the 17 states being considered in this paper (Kunz and Purcell 1981, 1982a, 1982b). Introducing their studies they said:

> "The concept of 'value added' has been used in manufacturing and fabrication, but generally not applied to the farming sector. However, as crop and animal production activities approach manufacturing in character, the concept of 'value added' becomes highly useful in evaluating the relative importance of farm production activities. Industrial inputs and interfarm transfer of inputs are becoming progressively more important in the farm sector.
>
> "Wealth created in farming accrues in commodities created by specific production activities. All production activities require personal initiative (labor and management), a land base and durable capital goods (buildings, machinery, equipment, tools, etc.). Also, most production activities consume or modify other products that contain market determined values (prices). The latter products, used in this production process and replaced each production cycle, are defined as consumed inputs. The difference between the value of the final production and the value of the consumed inputs (the value added) accrues to the local economy as returns to labor-management, the stock of durable capital, and the land base.
>
> "Such returns (value added) may be disbursed as payments for hired labor, durable capital, land improvements, property and other taxes, interest on borrowed funds, insurance, overhead, etc., or retained as profit (loss). Profit (loss) is a return for undertaking a risk bearing activity (enterprise)....
>
> "Estimates of 'value added' or value created ... are those values created by on-farm production processes....Value added or created is a more appropriate measure of the value of a particular production activity than is gross value of the product or cash receipts. Gross value contains considerable double counting of the value created by farm production activities while cash receipts shifts the emphasis to the final product."

The final product, especially livestock, is in fact credited for much value of production created by crops consumed. Value added credits livestock for value produced by range or other unharvested forages, but not for value of crops consumed.

Describing procedures Kunz and Purcell said:

> "Estimates of area seeded (crops), inventory (animals), yield (crops), production, farm prices (price received by producers), aggregate value (value of production), cash receipts by commodity, and other data are published on a continuing basis by the Statistical Reporting Service and the Economic Research Service of the U.S. Department of Agriculture....
>
> "The Economic Research Service of the U.S. Department of Agriculture and most State Agricultural Experiment Stations and Extension Services develop production budgets. These budgets contain information on the quantity and price of inputs (products) consumed in the production activities (commodities). A factor for "value added" or value created was derived from each budget. (F(VA) = 1-VCI/VP; F is the factor for value added, VCI is the value of consumed inputs, and VP is the value of the product for the specified budget.) The state aggregate value for each commodity (enterprise activity) was adjusted by the factor for value added to obtain the estimate of value added or created by the production activity."

One criticism which can be directed at this value added work is that it is for a single year, 1979. The volume of work required in this study of all 48 states precluded use of several years. The year used, 1979, was the most recent for which data were available, but was also a year of unusually high prices for cattle, sheep and wool. Hay and some other crop prices were strong based on Wyoming as an example, but not higher than in some previous years such as 1974 and 1976.

Value added by "livestock", hay and all other activities are summarized in Table 3 and Appendix Table 5. Livestock includes cattle, sheep and wool. It does not include milk production, swine or any type of poultry. Hay is reported because it is the major harvested forage input for beef cattle and range sheep. Obviously, some hay is used by dairy cattle and some in feedlots. Most of the hay can only be used by beef cattle, with a little by sheep. The calculation of value added

by livestock is net of value added by hay, but without the livestock there would be little value added by hay. With reduced rangelands use there could be continued use of some hayland and conversion of other to grazing, but only with great reductions in value added.

The Pacific region is dominated by California, with much of the value added from production activities other than cattle, sheep, wool or hay. The livestock-hay complex did account for 17% of value added in agriculture in the Pacific region in 1979.

Table 3. Relative importance of livestock and hay production activities in the farm sector, various states and regions, 1979.

Region and Production Activity	Value Added: Total $ Million	Value Added: Percent of Total
Pacific		
Livestock	921.237	10.1
Hay	624.868	6.9
All Other	7,538.962	83.0
Total	9,085.067	100.0
Rocky Mountain		
Livestock	2,134.477	37.8
Hay	852.403	15.1
All Other	2,653.067	47.1
Total	5,639.947	100.0
Plains		
Livestock	5,463.997	29.6
Hay	1,277.057	6.9
All Other	11,731.251	63.5
Total	18,472.305	100.0
3 Regions Total		
Livestock	8,519.711	25.7
Hay	2,754.328	8.3
All Other	21,923.280	66.0
Grand Total	33,197.319	100.0

Sources:

Kunz, Janice J. and Joseph C. Purcell. 1981. "Value Added (Created) in Southern Region USA Agriculture." IR-6 Information Report No. 34. Interregional Cooperative Publication of the State Agricultural Experiment Stations. August.

Kunz, Janice J. and Joseph C. Purcell. 1982. "Value Added (Created) in North Central Region USA Agriculture." IR-6 Information Report No. 58 Interregional Cooperative Publication of the State Agricultural Experiment Stations. April.

Kunz, Janice J. and Joseph C. Purcell. 1982. "Value Added (Created) in Western Region USA Agriculture." IR-6 Information Report No. 59 Interregional Cooperative Publication of the State Agricultural Experiment Stations. July.

In the Rocky Mountain region livestock and hay account for about 53% of value added. Data for Montana, Nevada, Wyoming and New Mexico are as follows:

Montana, Nevada, New Mexico and Wyoming

	Value Added: Total $ Million	Value Added: % Total	Value of Production: Total $ Million	Value of Production: Percent of Total
Livestock	1,103.792	49.9	1,625.506	50.0
Hay	411.447	18.6	523.078	16.1
All Other	695.193	31.5	1,100.266	33.9
Total	2,210.432	100.0	3,248.850	100.0

Obviously these states are heavily dependent on the livestock-hay-forage complex, with about 68% of the value added from these sources. Wyoming and Nevada have about 80 and 86% of value added by livestock and hay. In the Rocky Mountain region only Arizona and Colorado had higher value added from other products than from livestock and hay.

Among six plains states value added from livestock and hay amounted to about 36% of the total. The percentages for individual states were from less than 30% for Kansas and North Dakota to about 50% for Oklahoma and South Dakota.

Sources of Carrying Capacity

Although it is difficult to attribute production to different resources, it is possible to estimate sources of carrying capacity using Wyoming as an example:

Wyoming	AUM Equivalents (millions)
Requirements of cattle and sheep	21.0
Sources of forage resource	
Hay, 1.88 million tons at 3.0 to 3.3 AUM equivalents per ton	5.6
Hay aftermath, 1.1 AUM per acre	1.2
Other crop aftermath	1.0
Public rangelands active use (approx.)	2.4
Private rangelands, farm waste, sub-marginal wet meadows, etc.	10.8

Hay is sufficient for about 27% of total requirements. Aftermath provides about 1.0 AUM or a little more per acre of hay harvested. Aftermath from other crops is slight, except for sugar beet tops and a small amount of corn harvested for grain. There is a significant carrying capacity on wetlands that are sub-marginal for hay production, but very little of bona fide improved irrigated pastures.

Public lands provide about 11% of the total requirement or 20% of the total from rangelands. A "best" estimate is about 10 million AUM from private rangelands. That is about .3 to .33 AUM per acre, or about 3.0 to 3.3 acres per AUM, which is consistent with the average productivity of privately owned rangelands in the state.

Data for two other states with small dairy industries, Montana and New Mexico, are as follows:

	Million AUM Equivalent	
	Montana	New Mexico
Required for cattle and sheep	37.3	20.2
Provided from hay, at 3 AUM per ton	10.4	3.2
From other sources	26.9	17.0

Hay supplies about 28% of required capacity in Montana, but only about 16% in New Mexico. No further partitioning between aftermath and public and private ranges will be attempted for these states. Montana may be quite similar to Wyoming in total. Because of season-long use, rangeland in New Mexico may contribute a higher percentage of carrying capacity than in Montana or Wyoming.

Ranch Costs

Occasionally costs become the focus and reason for predictions of industry decline. When considering costs it is important to carefully specify costs included. Data on costs and returns per cow for a cow-yearling ranch in Wyoming are summarized below:

	Per Cow	
	1978-81	1981
Receipts	$393	$355
Cash costs (debt-free)	210	244
Net cash income	183	111
Depreciation	43	45
Net ranch income	140	66
Allowance for operators labor and management	57	59
Return to capital	83	7
Interest on working capital	96	134
Return to fixed capital	(13)	(127)

Through the years 1978-81 a ranch free of debt or with only a small debt could produce a reasonable return to operators labor and management, but no return to fixed capital. Land appreciated about 35% during the period. In 1981 and surely in 1982 returns are much reduced.

If the operation is treated as an enterprise, as is sometimes done, charges for operators labor and management, working capital used, and for land result in large losses. It must be recognized that cost items to the livestock enterprise for labor, management and capital are returns to the operator and his capital. Alternative opportunities for operators labor and management, and certainly for the land resources are limited. Most of those costs are fixed. Theory teaches that production will continue in the short run if variable costs are covered. We should not project large changes in resource use yet.

Everyone doesn't make a profit every year in a perfectly competitive free enterprise system. That has been true of operators of small and large business, buyers of penny stocks and petroleum or oil well service stocks, etc. Livestock feeders have a history of operating above break-even levels less than half the time. Should more be expected in the range livestock industry stage of production? Are there any principles or logic to support arguments for guaranteed returns?

Implications

Occasionally one hears that the livestock industry in the west cannot compete with that in the mid-west or southeast. A few things seem clear:

(1) there is a very large resource base for production of hay and range forage in these 17 states;

(2) there are few bona fide alternative uses for most of these resources, even conceding the possibility of recreational uses on some;

(3) the ruminant animals are the only animals capable of utilizing the forage from these types of resources; and,

(4) much of the resource base, especially that from the east side of the Rocky Mountains to the west side of the Sierra Nevada Mountains is ill-adapted to intensive use of labor and capital inputs, in spite of federal agency talk for the last 16 years or so about intensive management;

(5) privately owned rangelands provide much more of the forage resource than do the publicly owned lands, are generally more productive of forage and more amenable to management. Major research emphasis should be toward management and improvement of this resource.

The indications to a non-modeler are that the industry will go on, utilizing the resources, perhaps with some modifications and improvements in management and technology, but without any great changes in productivity of the basic resource.

CONSUMPTION

Production has been treated on a regional basis, though it occurs nationally. Consumption will be treated on a national basis.

A number of statements heard at a recent beef profits conference in Denver bear repeating.[1/] One thought expressed by a few speakers was "the beef cattle industry is now a mature industry. We shouldn't expect a great deal of further growth." The statement is probably true if the entire meat industry is considered. Total consumption per capita is as high or higher than it has ever been (Ikerd 1982). Ikerd's analysis also indicates the demand for all meats has been "consistent" (not shifting) through the last 20 years. There has been an increase of 30% in total meat consumption per capita but a 43% decrease in income deflated prices all occurring on a non-shifting demand curve for all meat.

1/ National Beef Profit Conference. Sponsored by the National Cattlemen's Association, Denver, Colo., June 27-29, 1982. The proceedings from that conference are not yet available. Some useful quotations are remembered, but cannot be identified with individual speakers.

The beef industry is concerned about shifting demands for beef and a loss of market share. Pork was the most popular meat in the United States during the first half century (Ikerd 1982). Beef was higher priced, less plentiful and much was not the high quality we have now, but grass fed or cull cattle, including dairy stock. Chicken was for special occasions.

Beef surpassed pork during the 1950's, and still brought premium prices, giving statistical evidence of a shift in consumer preferences. High quality from greater grain feeding was probably a factor. Consumption of chicken also increased greatly. That is more likely a response to much lower relative price, and probably the result of production efficiencies of the poultry industry, not an indication of basic change in preference.

Beef is being more seriously challenged since the mid-1970's. Retail pork prices averaged almost 75% of retail beef prices from 1962 to 1981, but averaged only 64% of beef prices since 1978 (Drabenstott and Duncan 1982). Retail poultry prices averaged only 41% of beef prices during the past two decades, but only 30% of beef prices during the past three years. Concurrent with these relative price declines, pork and poultry consumption have increased, contributing to beef industry concern.

Relative retail prices are consistent with total production costs per lb. liveweight for 1972-80 (Trapp 1982):

	Cents per lb. - 1972-80	
	Costs	Net Return
Beef	50.57	-3.97
Pork	42.60	-1.04
Chicken	21.60	2.12

Costs are for the feeding (fattening) stage for beef and for the entire production period for pork and chicken.

Returns were quite variable and averaged negative for beef and pork. Returns were consistent, relatively small and averaged positive for chicken. It is relatively easy to adjust output of chicken and costs are more completely under control of the integrated producer. Output and costs of production of total beef, not just fed beef are adjusted slowly.

Another thought expressed at the Beef Profit Conference was "the further we look back, the better we are able to see ahead." This and the quote on "maturity" seem appropriate leads for discussion of the future of the consumption side of the livestock industry. Extensive use of visual materials from the Western Livestock Marketing Information Project will simplify this discussion.

On Maturity of the Livestock Industry

The maturation and changes in the livestock and meat supply industries can perhaps be indicated by considering fed cattle marketings which increased from about 10 million head in 1955 to over 26 million in 1972 (Figure 1). They have fluctuated with the cattle cycle since then. We should expect that to continue in the future, if the industry is in fact mature.

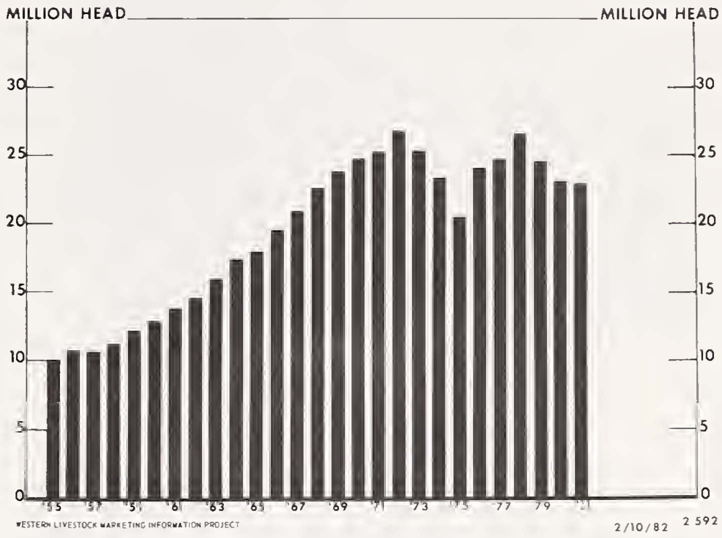

Figure 1. Fed cattle marketings (23 states), 1955 - 1981.

Commercial cattle slaughter is shown in Figure 2. It reflects increased cattle feeding from 1965 until 1972 and maturity in that industry since then. Slaughter lags behind the cattle numbers cycle slightly. Slaughter remained quite high through 1978 and has been much lower since then. Non-feed steer and heifer slaughter was reduced as feeding increased, and since reaching a low point in 1973 has been a "shock absorber" varying with cattle numbers and concentrate feed supply conditions. Slaughter of cull cows and bulls is closely related to the cattle numbers cycle.

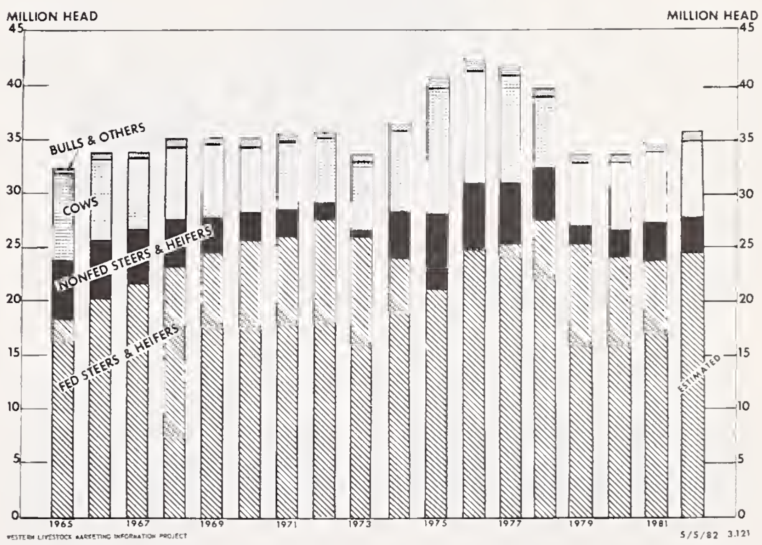

Figure 2. Commercial cattle slaughter, 1965 - 1982.

Production of red meats is shown in Figure 3, and per capita consumption of red meats poultry/and fish is shown in Figure 4. Changes in production and consumption will be seen more clearly on separate subsequent charts.

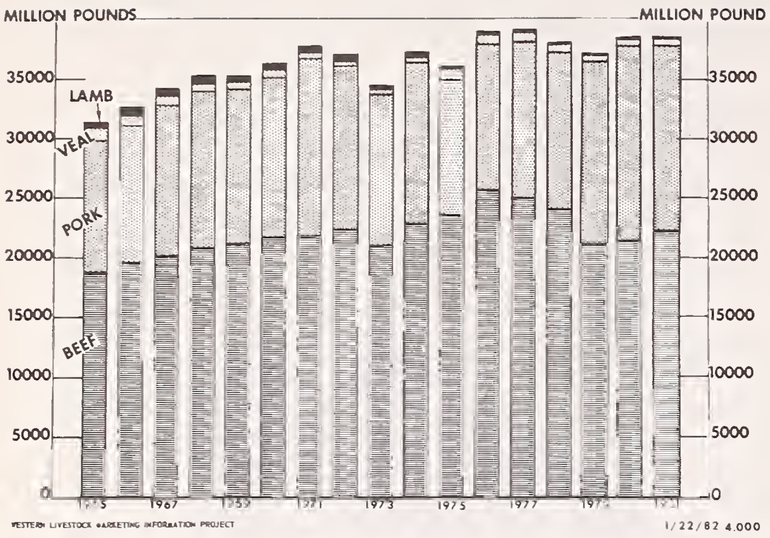

Figure 3. Production of red meat.

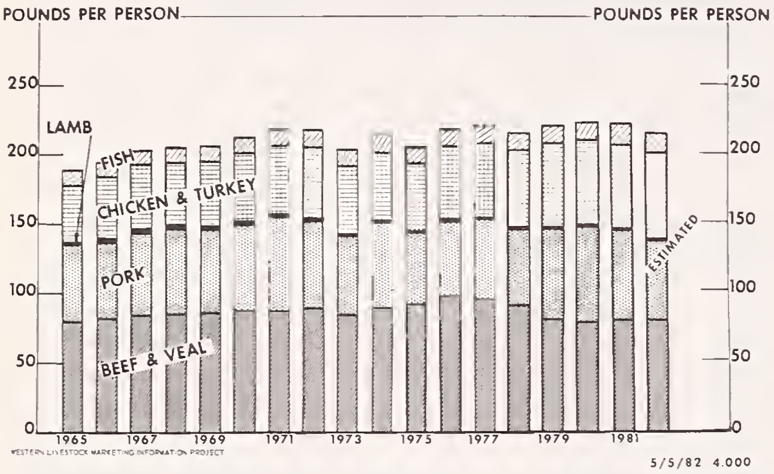

Figure 4. Consumption of meat, poultry, & fish, 1965 - 1982, retail weight equivalent.

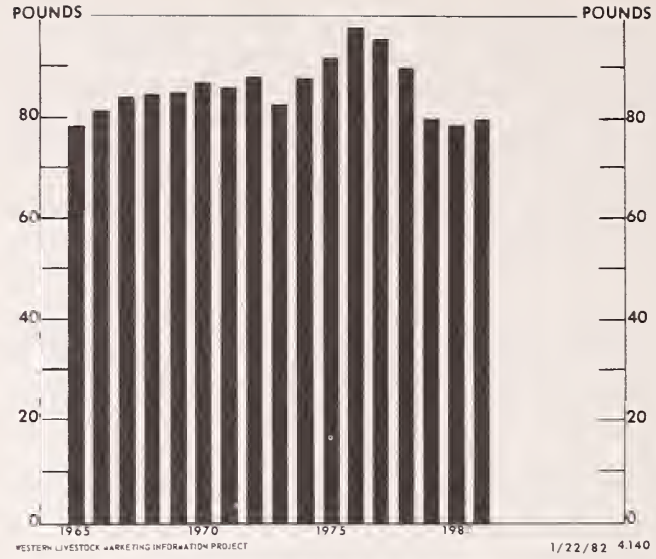

Figure 5. Beef consumption per person, 1965 - 1981 (retail weight).

Figure 6. Pork consumption per person.

Beef

Beef consumption per capita is shown in Figure 5. An old and simple concept bears repetition. Whatever is produced will be consumed. Consumption of beef is consistent with the cattle cycle. Beef consumption declined from 47% to 37% of the total red meat and chicken between 1976 and 1980 (Ikerd 1982). Ikerd suggested that beef demand has shifted as market share shifted, with a downward shift in demand recently.

Pork

Pork consumption per capita is shown in Figure 6. Recently some concern has been expressed by beef producers about a resurgence of preference for and consumption of pork. If a short-term view is taken, say 1975 to present, their concern appears justified as the pork share of consumption increased from 27% in 1976 to 33% in 1980. If we look a little further back, the swine industry is also seen as "mature".

Poultry

Poultry consumption per person is shown in Figure 7. For 1950-54 consumption of chicken and turkeys averaged about 22 lb. and 6 lb. By 1965 consumption had increased to about 34 lb. of chicken and 8 lb. of turkey. It is now about 50 lb. of chicken and 10 lb. of turkey, with some suggestion of impending maturity of that industry. The poultry share increased from 27% to 30% between 1976 and 1980.

Implications

Recently there have been comments that the problems for the beef industry have stemmed from a decline in real expenditures for beef, per capita. That problem is not unique to beef, but is common to pork and poultry, as well, and is a result of rising total incomes, a "stomach capacity" limit, and an abundance of meat.

Pork and poultry cost less to produce than beef. They also cost less at the retail market. There is still a question, perhaps a divergence of opinion about consumer preferences for beef vis-a-vis pork and poultry. Beef has lost a significant amount of total meat market share, but much of that loss is tied to the cattle cycle and expanding hog cycle.

Market share gains of chicken have been persistent through two decades. The real problems seem to be the large supply of total meat depressing prices, not any real shift in preferences or demand for total meats, nor any very significant shift in demand for beef. The fact that beef had held most of its market share at much higher prices than for other meats is still encouraging.

A high level of exports seem necessary for agriculture and for other nations.

The natural gas pipeline from the Soviet Union to Eastern and Western Europe could increase Soviet gas exports three fold to Western Europe and by 50% to eastern Europe (Minard 1982). That could have favorable implications for agricultural exports.

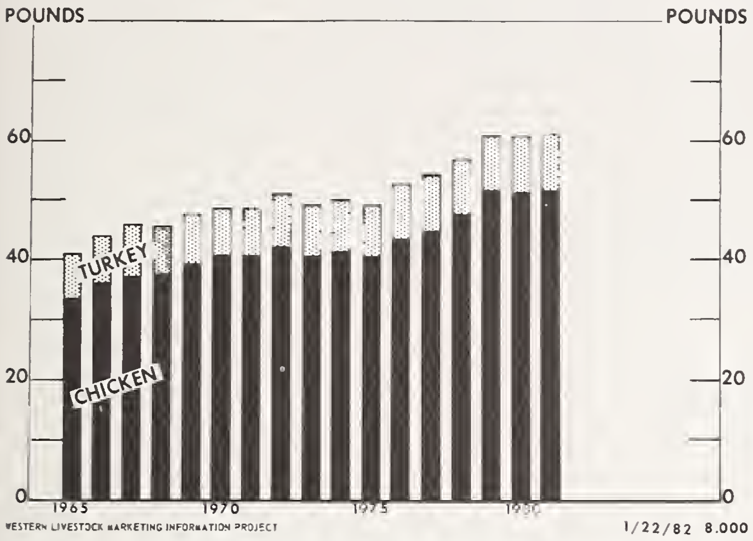

Figure 7. Poultry consumption per person 1965 - 1981.

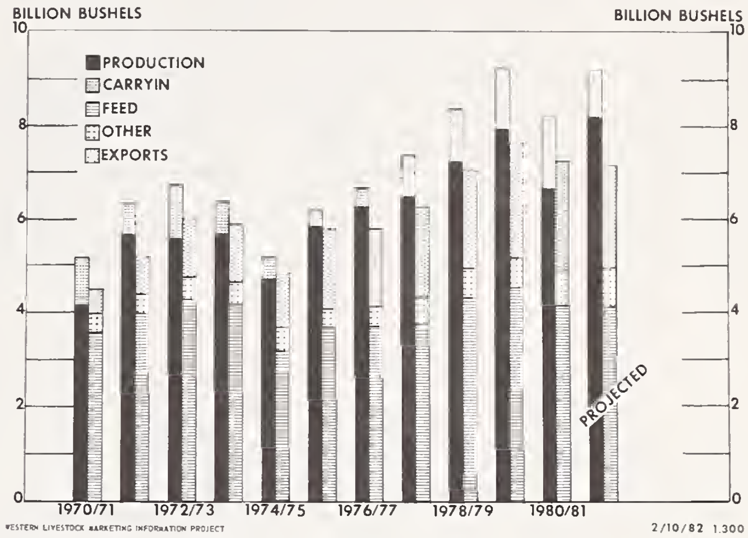

Figure 8. Corn supplies & utilization, 1970 - 1981.

FEED GRAINS

When considering the production side, hay was mentioned as part of the forage supply, and an important consideration in the economics of range livestock areas. Obviously, hay is mostly utilized at the locations of production. Certainly there is little movement of hay for use by beef cattle or sheep.

Feed grains, mostly corn but also including grain sorghums, barley and oats, are used extensively for feeding beef cattle and to a limited extent in the breeding herd or range beef cattle stages. Unlike hay, feed grains also move in national and international markets. The future for feed grains is certainly relevant to the future of the range livestock industries. For the 1981-82 marketing year total use of feed grains excluding food, alcohol and seed is expected to be:

	Billion bushels
Corn	6.3
Sorghums	.7
Barley and oats	.8

Because of the pre-eminent position of corn it will be used as a proxy for all feed grains.

Corn supplies and utilization are shown in Figure 8. Production was quite low in 1970, 1974 and 1980. Feed use varies with production (inversely with prices) and is affected by the cattle and hog cycles. The most notable changes are in exports, which are shown more clearly in Figure 9. Exports have increased from about .5 billion bushels in 1970 to 2.4 billion bushels in 1980. In effect exports provided the outlet for increased feed production after 1972 as cattle feeding "matured".

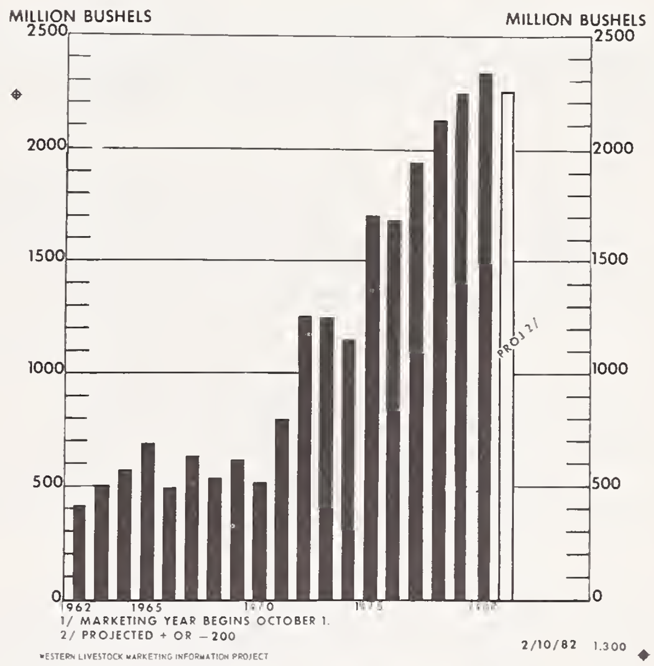

Figure 9. U.S. corn exports, 1962 - 1981.

ENERGY, RANGELANDS AND AGRICULTURE

One finds varying and frequently changing interpretations of the current reality and extent of "energy crisis." Some people, thinking twenty years ahead, still see energy scarcity as a matter of real concern. Coal and petroleum are stock resources which resulted originally from photosynthesis processes and were ultimately converted to the present form by other processes. Petroleum exporting countries are exhausting a stock resource which often represents a major part of their known resources. It seems quite logical for them to restrict the volume of petroleum output, extend

the time period over which the output will be available, and extract a high price as output is being produced.

The production of crops represent ways of capturing solar energy and harvesting it in a storable, transportable form. Production of range forage represents solar energy which is captured only to the extent that the forage is utilized efficiently. The present price situation may suggest a short-term and short-sighted solution of reduction of grazing and of livestock production. The longer-term and better solution I believe, should involve an increased reliance on and more efficient use of range forages to make an increased supply of feed grains available for export. That, in turn, provides a means of acquiring supplies of stock resources, energy, and other goods from other countries.

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NOTE: APPENDIX TABLES FOLLOW.

In: Wagstaff, Fred J., compiler. Proceedings--range economics symposium and workshop; 1982 August 31-September 2; Salt Lake City, UT. Gen. Tech. Rep. INT-149. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983.

Appendix Table 1. Cattle inventory numbers in the western and great plains states, 1972-81 averages January 1. (1,000 head)

State and Region	1/ Cows: Beef	1/ Cows: Milk	2/ Replacements: Beef	2/ Replacements: Dairy	3/ Steers and Heifers	4/ Calves	Bulls	All Cattle & Calves	Calves born	Cattle fattening: on feed	Cattle fattening: 5/ Marketed
Pacific											
California	973	828	225	316	378	1,105	78	4,801	1,605	898	1,682
Oregon	650	93	111	32	129	401	42	1,536	672	78	148
Washington	381	187	85	73	163	311	27	1,395	519	168	369
Sub-total	2,004	1,108	421	421	670	1,817	147	7,732	2,796	1,144	2,199
Rocky Mountain											
Arizona	317	65	46	15	46	257	26	1,208	313	436	749
Colorado	986	74	187	30	274	759	60	3,316	946	946	2,138
Idaho	642	148	112	74	150	542	41	1,935	752	226	424
Montana	1,562	29	279	10	168	747	90	2,982	1,591	97	144
Nevada	322	14	51	7	30	156	17	627	280	30	5/
New Mexico	637	34	105	10	93	448	40	1,566	591	199	335
Utah	335	77	55	40	55	224	18	861	366	57	5/
Wyoming	716	13	138	3	104	438	44	1,501	692	45	5/
Sub-total	5,517	454	973	189	920	3,571	336	13,996	5,531	2,036	3,790
Plains											
Kansas	1,834	140	266	47	1,125	1,734	94	6,470	1,816	1,230	2,834
Nebraska	2,103	143	310	38	689	1,762	114	6,720	2,069	1,561	3,662
North Dakota	1,063	112	157	25	176	623	55	2,251	1,163	40	74
Oklahoma	2,324	120	362	36	801	1,712	122	5,777	2,183	300	648
South Dakota	1,731	165	245	45	261	1,389	90	4,287	1,853	361	572
Texas	6,169	331	1,009	100	968	3,957	422	14,836	5,614	1,880	4,153
Sub-total	15,224	1,011	2,349	291	4,020	11,177	897	40,341	14,698	5,372	11,943
17 State Total	22,745	2,573	3,743	901	5,610	16,565	1,380	62,069	23,025	8,552	17,932
U.S. Total	40,535	11,132	6,874	3,990	10,881	31,456	2,596	120,290	46,735	12,826	24,242

Sources: See Table 1.

1/ Cows that have calved
2/ Heifers or steers over 500 lbs.
3/ Steers and heifers over 500 lbs not on feed.
4/ Calves under 500 lbs.
5/ Average marketed 1972-1980. Information not available for all states.

Appendix Table 2. Production, value of production, prices and AUM equivalents of calves, western and great plains states, 1972-1980

State and Region	Production Amount	Production Value	Average Prices (per cwt) Cattle	Average Prices (per cwt) Calves	AUM Equivalent	Per AUM Equivalent Production	Per AUM Equivalent Value
Pacific	(million lb)	($ million)	(dollars)	(dollars)	(thousands)	(lb)	(dollars)
California	1,797	793	44.67	47.07	57,612	31.19	13.76
Oregon	498	212	41.18	46.30	18,432	27.02	11.50
Washington	423	190	43.03	43.35	16,740	25.27	11.35
Sub-total	2,718	1,195			92,784	29.29	12.88
Rocky Mountain							
Arizona	620	286	45.43	50.87	14,496	42.77	19.73
Colorado	1,700	798	46.92	54.78	39,792	42.72	20.05
Idaho	672	312	44.87	52.60	23,220	28.94	13.44
Montana	981	440	42.49	53.46	35,784	27.41	12.30
Nevada	189	84	42.27	50.28	7,524	25.12	11.16
New Mexico	620	291	46.44	50.29	18,792	32.99	15.49
Utah	254	107	40.63	50.50	10,332	24.58	10.36
Wyoming	515	236	45.00	55.82	18,012	28.59	13.10
Sub-total	5,551	2,554			167,952	33.05	15.20
Plains							
Kansas	2,689	1,201	44.50	51.66	77,640	34.63	15.47
Nebraska	2,479	1,263	45.10	52.52	80,640	30.74	15.66
North Dakota	839	366	42.88	53.08	27,012	31.06	13.55
Oklahoma	2,109	929	43.51	51.62	69,324	30.42	13.40
South Dakota	1,724	785	45.07	54.70	51,444	33.51	15.26
Texas	5,162	2,247	43.38	50.06	178,032	28.99	12.62
Sub-total	15,002	6,791			484,092	30.99	14.03
17-States	23,271	10,540			744,828	31.24	14.15
U.S.	40,754	17,645			1,443,480	28.23	12.22

Sources: See Table 1.

Appendix Table 3. Sheep, lambs and wool western and great plains states - 1972-81 average inventories, 1972-80 average production and value (thousands of all units, numbers, lb., or dollars).

State and Region	Total stock sheep	Lambs and sheep on feed	All sheep and lambs	Production Lambs and sheep	Production Wool	Value of Production Lambs and sheep	Value of Production Wool	Value of Production Total
Pacific	(number)	(number)	(number)	(lb)	(lb)	(dollars)	(dollars)	(dollars)
California	961	165	1,126	67,721	10,642	31,363	7,164	38,527
Oregon	368	95	463	25,976	3,440	10,598	2,333	12,931
Washington	84	10	94	5,451	871	2,322	544	2,866
Sub-total	1,413	270	1,683	99,148	14,953	44,283	10,041	54,324
Rocky Mountain								
Arizona	362	90	452	20,113	2,957	7,763	1,576	9,339
Colorado	555	405	960	70,788	9,233	33,455	6,062	39,517
Idaho	537	36	573	47,054	5,777	19,955	3,759	23,714
Montana	629	66	695	31,146	5,859	11,637	4,367	16,004
Nevada	135	15	150	8,338	1,283	3,429	842	4,271
New Mexico	594	40	634	18,330	5,374	8,073	3,661	11,734
Utah	655	40	695	36,070	6,566	15,051	4,124	19,175
Wyoming	1,166	146	1,312	50,083	12,087	19,696	8,334	28,030
Sub-total	4,633	838	5,471	281,922	49,136	119,059	32,725	151,784
Plains								
Kansas	168	67	235	14,544	1,924	6,403	1,107	7,510
Nebraska	150	111	261	14,420	1,828	5,869	1,035	6,904
North Dakota	219	69	288	15,643	2,174	6,012	1,358	7,370
Oklahoma	74	20	94	5,083	652	2,135	360	2,495
South Dakota	775	74	849	65,194	7,670	27,892	5,235	33,127
Texas	2,492	235	2,727	124,311	22,462	49,418	17,104	66,522
Sub-total	3,878	576	4,454	239,195	36,710	97,729	26,199	123,928
17 States	9,924	1,684	11,608	620,265	100,799	261,071	68,965	330,036
U.S.	12,321	2,057	14,378	784,217	120,802	330,542	79,797	410,339

Sources: See Table 1.

"Sheep, Lambs and Goats: Final Estimates for 1976-79." Economics and Statistics Service. Statistical Bulletin 653. U.S. Department of Agriculture.

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Appendix Table 4. AUM's required for sheep and lambs and 1972-80 average production and value of production per AUM equivalent in the western and great plains states (lb. and dollars)

State and Region	AUM's	Production per AUM: Lambs and sheep	Production per AUM: Wool	Value of Production per AUM: Lambs and sheep	Value of Production per AUM: Wool	Value of Production per AUM: Total
	(thousands)	(lb)	(lb)	(dollars)	(dollars)	(dollars)
Pacific						
California	2,388	28.36	4.46	13.13	3.00	16.13
Oregon	930	27.93	3.70	11.40	2.51	13.91
Washington	208	26.21	4.19	11.16	2.62	13.78
Sub-total	3,526	28.12	4.24	12.56	2.85	15.41
Rocky Mountain						
Arizona	914	22.00	3.23	8.49	1.73	10.22
Colorado	1,535	46.12	6.01	21.79	3.95	25.74
Idaho	1,307	36.00	4.42	15.27	2.88	18.15
Montana	1,543	20.18	3.80	7.54	2.83	10.37
Nevada	332	25.11	3.86	10.33	2.54	12.87
New Mexico	1,446	12.68	3.72	5.58	2.53	8.11
Utah	1,592	22.66	4.12	9.45	2.59	12.04
Wyoming	2,871	17.44	4.21	6.86	2.90	9.76
Sub-total	11,540	24.43	4.26	10.32	2.84	13.16
Plains						
Kansas	436	33.36	4.41	14.69	2.54	17.23
Nebraska	416	34.66	4.39	14.11	2.49	16.60
North Dakota	560	27.93	3.88	10.74	2.42	13.16
Oklahoma	188	27.04	3.47	11.36	1.91	13.27
South Dakota	1,897	34.37	4.04	14.70	2.76	17.46
Texas	6,099	20.38	3.68	8.10	2.80	10.90
Sub-total	9,596	24.93	3.83	10.18	2.73	12.91
17 States	24,662	25.15	4.09	10.58	2.80	13.38
U.S.	30,599	25.63	3.95	10.80	2.61	13.41

Appendix Table 5. Relative importance of livestock and hay production activities in the farm sector, various states and regions, 1979.

Region and Production Activity	Value Added ($ Millions): Livestock	Value Added ($ Millions): Hay	Value Added ($ Millions): Other	Value Added ($ Millions): Total	Percent of Total: Livestock	Percent of Total: Hay	Percent of Total: Other
Pacific							
California	547.544	420.324	5,861.789	6,829.657	8.0	6.2	85.8
Oregon	227.660	91.590	505.411	824.665	27.6	11.1	61.3
Washington	146.033	112.950	1,171.762	1,430.745	10.2	7.9	81.9
Sub-total	921.237	624.868	7,538.962	9,085.067	10.1	6.9	83.0
Rocky Mountain							
Arizona	151.522	79.969	510.494	741.985	20.4	10.8	68.8
Colorado	491.913	103.528	594.989	1,190.430	41.3	8.7	50.0
Idaho	291.880	180.969	728.533	1,201.382	24.3	15.1	60.6
Montana	496.949	212.229	434.373	1,143.551	43.4	18.6	38.0
Nevada	77.561	63.044	23.463	164.068	47.2	38.4	14.4
New Mexico	249.689	50.120	149.408	449.217	55.6	11.2	33.2
Utah	95.370	76.490	123.858	295.718	32.1	25.8	42.1
Wyoming	279.593	86.054	87.949	453.596	61.6	19.0	19.4
Sub-total	2,134.477	852.403	2,653.067	5,639.947	37.8	15.1	47.1
Plains							
Kansas	798.284	240.598	2,492.764	3,531.646	22.6	6.8	70.6
Nebraska	917.249	291.129	2,279.041	3,487.419	26.3	8.4	65.3
North Dakota	406.456	168.548	1,484.999	2,060.003	19.7	8.2	72.1
Oklahoma	851.782	163.387	1,082.460	2,097.629	40.6	7.8	51.6
South Dakota	837.834	212.735	1,065.268	2,115.837	39.6	10.0	50.4
Texas	1,652.392	200.660	3,326.719	5,179.771	32.0	3.9	64.1
Sub-total	5,463.997	1,277.057	11,731.251	18,472.305	29.6	6.9	63.5
3 Regions Total	8,519.711	2,754.328	21,923.280	33,197.319	25.7	8.3	66.0

Sources: See Table 3.

RANGELAND AS A COLLECTIVE CAPITAL GOOD

Richard E. Howitt

ABSTRACT: Collective goods are defined as having nonconvex transaction costs. In this case property rights alone do not ensure an efficient supply of several range outputs, wildlife, recreation, and watershed catchment. Recognition of the stock nature of rangeland requires a capital theory model to analyze the incentives for efficient rangeland production under alternative institutions.

INTRODUCTION

The agencies administering public rangelands are currently on the political defensive against advocates of a sweeping change towards private ownership. The sagebrush revolutionaries infer that the logic of economic efficiency is behind their proposition (Libecap 1981). This paper takes the viewpoint of a newcomer to this branch of resource economics in using a theoretical approach to address the following questions. First, are there inherent properties of some of the multiple uses of public rangeland that make them collective goods? That is, goods that will not be supplied by a private market. Second, what is the theoretical basis for inefficiencies imposed on the livestock sector by publicly administered rangelands? What system of property rights would reduce these inefficiencies? Third, given the trends of increasing demands for nonlivestock range uses, will the ratio of the costs of government failure to market failure increase or decrease over time?

While there is a long history of research into these questions, and, I am glad to say, the results will be intuitive to all of you, I think it important to establish the theoretical basis for claims of economic efficiency. Since the grazing industry depends on a flow of productivity from the range but many other uses; wildlife, recreation, and watershed values depend on the stock of biomass on the range, recognition of the capital nature of the problem is needed. Stevens and Godfrey (1972) state "The physical productivity of investments and the responsiveness of resource flows to prior use rates are particularly important . . . The actual realization of increased use rates, however, depends upon the institutional and incentive frameworks of the decision maker."

Stevens and Godfrey suggested an approach to analyzing their dynamic model, but concentrated on empirical results for a static version of the model. This paper makes a theoretical attempt to obtain the dynamic qualitative properties of the economic incentives under the alternative institutions of private ownership and public regulation. The range management problem is essentially one of optimum capital use and accumulation. However, I am not aware of a capital theory approach to range management other than Stevens and Godfrey (1972) and Burt (1971). Given the subsequent comments in the literature to Burt's article [Bromley (1972), Martin (1972)] it is clearly dangerous ground and I must trust that the theory is more pratical and the data more available than ten years ago.

COLLECTIVELY SUPPLIED GOODS

Arrow (1969) argues that externalities can be eliminated by a sufficiently comprehensive set of markets, while at the other extreme Heller and Starrett (1976) point out that in a pure barter economy all effects are externalities under the conventional definition of interdependent production (or utility) functions. Clearly the conventional definition of externalities is not useful, and Coase's (1960) seminal article by its assumption of zero transaction costs explains the reason. Externalities occur when markets are absent, and markets are absent when transaction costs are prohibitively high. By transaction costs I mean the costs of defining the property rights, negotiating a trade, transferring the property right and enforcing the trade.

It is a short step from this definition of externalities to the logic that since it is unprofitable to establish private markets, efforts to internalize the externalities through social regulation are inherently inefficient and can only be justified on distributional grounds. The property rights equivalent of the Coase theorem is that given a sufficiently rich set of property rights all economically efficient goods will be supplied. Two critical implicit assumptions underlie this argument. First, that the appropriate transaction cost technology is convex and thus transactions are private goods to be supplied like any other. Second, that the public transaction costs are similar to private transaction costs. That is, there are no economies of scale in transacting.

Foley (1970) has shown that efficient equilibria exist when the transactions technology is convex, and Starr (1969) shows that quasi-equilibria can be achieved if transaction costs are small relative to the market. Given my definition of transaction costs which requires the setting up of market institutions, it is clear that the fixed costs involved violate the convexity requirement. Furthermore, since the transaction costs determine the existence of markets, they cannot be

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characterized as relatively small. One can therefore conclude that if the market transaction costs are significant and nonconvex, a full set of property rights is a necessary but not sufficient condition for efficient market allocation. If, for instance, the nonconvex transaction technology was only caused by institutional set up costs, then externality inefficiencies would exist until publicly supplied institutions moved the market to the convex part of the transactions cost function. A classical example of this phenomenon is that of colonial traders following the collectively supplied gunboats.

Do the nonlivestock range uses of recreation, wildlife, and watershed with their attendant option demands have these properties that ensure that they are not supplied by a private market system, but can be efficiently supplied as collective goods? Heller and Starrett (1976) show that the nonconvexities can be caused by violation of either additivity or divisibility in the production set. Recreation on large areas of rangeland is clearly a nondivisible good in its production, most particularly when the attributes sought by the recreation are those of space and solitude. Attempts to divide this commodity would totally change the nature of the good.

Wildlife on the range has many private goods characteristics when hunting areas are delineable and charges can be levied per unit of access or kill. There are other wildlife constraints and values on the range that are not divisible into market units, many of these uses are comparatively recent and represent demands for the existence of habitat for raptors or wild horses and burros, etc. (Johnston and Yost 1979). The demand for these habitats has the property of an option demand in that actual contact with these wild species is rare. These option demands are indivisible and largely nonexchangeable, thus violating convexity properties both in production and consumption. Brookshire, Eubanks and Randall (1979) have developed methods to measure option demands.

The value of public rangelands as water catchments is being increasingly recognized as the scarcity of western water resources increases, while increased runoff is often a joint product of rangeland pasture improvements, production of usable water from an area is subject to indivisibilities and problems of defining the boundaries of catchment areas especially when all or part of the flows are subsurface.

Mineral exploration and development are competing uses with livestock and other collective outputs from rangeland, but the nature of the technical externalities involved requires publicly constrained private development. The optimal level of exploration and development can be delivered by considering this activity as private production that jointly produces negative externalities on all the other rangeland uses.

Given the transaction problems caused by the divisibility, addivitity, and boundary delineation properties of many outputs of rangeland, a full set of property rights is not a sufficient condition for the private market supply of all efficient goods. This conclusion is based solely on considerations of technical efficiency in the economic system. Equity considerations are likely to further reinforce the qualitative conclusions.

It was argued earlier that property right institutions are discrete alternatives, with significant set up costs. Thus the optimum choice of institutions reduces to a benefit/cost comparison of reasonable alternatives. For contrast, two radical choices are considered. The system of central agency management prevalent over many Western ranges, versus the complete private ownership of the ranges by livestock producers advocated by some academicians, producers and politicians. The relative desirability of either institution depends on the ratio of the costs of "government failure" and "market failure" that will occur in each of these alternatives.

To return to the problem posed by Stevens and Godfrey (1972) a highly simplified dynamic model of the economics of multiple use rangeland is developed to examine the incentives under the institutional alternatives.

A SIMPLE DYNAMIC RANGELAND MODEL

A highly aggregated and simplified model of multiple use rangeland is specified with three state or stock variables and three control or decision variables. A minimal representation can be acheived by Y_{1t} range biomass in time t, Y_{2t} an index of the wildlife population and Y_{3t} the capital stock of improvements to the range grazing. The three control variables are U_{1t}, the livestock stocking rate in time t; U_{2t}, investment in range improvements; and U_{3t}, the intensity of hunting or control of the wildlife. It is assumed that the representative wildlife are herbivores and compete for range biomass with the livestock, but do not prey directly on the livestock.

The model objective function is divided into measure of private net revenues to livestock ranchers, $f_1(t, U_{1t}, U_{2t})$. Profit maximizing ranchers will therefore optimize the present value of the stream of discounted net revenues over a given horizon

$$(1)\ \text{Max} \int_{t_o}^{T} e^{-rt} f_1(t, U_{1t}, U_{2t})\, dt.$$

$$\frac{\partial f_1(\cdot)}{\partial U_1} > 0, \qquad \frac{\partial f_1(\cdot)}{\partial U_2} < 0$$

In this paper, the model will be specified in continuous time for simplicity of notation and time derivatives.

The public agency objective function is specified to maximize the present value of a monetary measure of collective utility from Y_{1t} the stock of range biomass when valued for recreational and aesthetic reasons, Y_{2t} the stock level of wildlife, and U_{3t} the intensity of hunting in any period. The collective goods objective of the managing agency is:

$$(2)\ \text{Max} \int_{t_o}^{T} e^{-rt} f_2(t, Y_{1t}, Y_{2t}, U_{3t})\, dt$$

$$\frac{\partial f_2(\cdot)}{\partial Y_1} > 0, \quad \frac{\partial f_2(\cdot)}{\partial Y_2} > 0, \quad \frac{\partial f_2(\cdot)}{\partial U_3} > 0$$

The time rate of change of the three state variables is described by three differential equations similar to the difference equations specified by Stevens and Godfrey. The dynamics are represented by:

$$\dot{Y}_1 = g_1(Y_{1t}, Y_{2t}, Y_{3t}, U_{1t}) \quad \frac{\partial g_1(\cdot)}{\partial Y_1} > 0,$$

$$\frac{\partial g_1(\cdot)}{\partial Y_2} < 0, \quad \frac{\partial g_1(\cdot)}{\partial Y_3} > 0, \quad \frac{\partial g_1(\cdot)}{\partial U_1} < 0$$

$$(3)\ \dot{Y}_2 = g_2(Y_{1t}, Y_{2t}, U_{1t}, U_{3t}) \quad \frac{\partial g_2(\cdot)}{\partial Y_1} > 0,$$

$$\frac{\partial g_2(\cdot)}{\partial Y_2} < 0, \quad \frac{\partial g_2(\cdot)}{\partial U_1} < 0, \quad \frac{\partial g_2(\cdot)}{\partial U_3} < 0$$

$$\dot{Y}_3 = g_3(Y_{3t} \cdot U_{2t}) \quad \frac{\partial g_3(\cdot)}{\partial Y_3} < 0, \quad \frac{\partial g_3(\cdot)}{\partial U_2} > 0$$

[Note, $\dot{Y}$ is defined as dy/dt in general.]

Collapsing the two objective functions into the vector function $F(\cdot)$ and the three equations of motion into $G(\cdot)$. The current value Hamiltonian is defined as:

$$(4)\ H_t = F(t, \underline{Y}\ \underline{U}) + e^{rt}\lambda_t\, G(t, \underline{Y}\ \underline{U})$$

where λ_t is a 3x1 vector of costate variables associated with the state variables. The costate variables can be shown to be equal to the marginal value over the whole horizon of the state variables at any given time. The optimal control problem of maximizing $F(t, \underline{Y}_t, \underline{U}_t)$ over the period $t_o - T$ subject to the initial conditions $\underline{Y}_{to}$ and the biological relationships represented by $G(t, \underline{Y}_t\ \underline{U}_t)$ is achieved by maximizing the Hamiltonian function at all time periods. The Pontryagin Maximum principle proves that the optimum path of actions $\underline{U}^*_t$ has to satisfy the following necessary conditions (Arrow and Kurz 1970; Kamien and Swartz 1981).

$$(5)\ \frac{\partial H_t}{\partial \lambda_t} = \dot{Y} \qquad \text{for all } t \qquad \text{Condition I}$$

$$(6)\ \frac{\partial H_t}{\partial U_t} = 0 \qquad \text{for all } t \qquad \text{Condition II}$$

$$(7)\ -\frac{\partial H_t}{\partial Y_t} = \dot{\lambda} \qquad \text{for all } t \qquad \text{Condition III}$$

If the costate is expressed in terms of current values it is defined as $\gamma_t \equiv e^{rt}\lambda_t$ and condition (III) becomes

$$(8)\ -\frac{\partial H_t}{\partial Y_t} = \dot{\gamma} - r\gamma_t$$

A brief interpretation of the Pontryagin conditions is that (5) requires that the time change of states must satisfy the biological relationships. Equation (6) says that since the biological constraints are embedded in the Hamiltonian H_t, an optimum solution requires an interior optimum with respect to the controls. Condition (8) determines the time rate of change of the marginal value of the stocks of rangeland capital. More specific interpretations are given in later sections.

This simplified model in continuous time may appear impractical but could be empirically implemented quite easily. The conversion to discrete time periods necessary for empirical estimates is straightforward and the first order simultaneous difference equations used in Stevens and Godfrey would be most appropriate for the growth functions $G(\cdot)$. The private value function of grazing and range improvements $f_1(\cdot)$ can be estimated from an appropriate range management study. The empirical function $f_2(\cdot)$ will be hard to accurately estimate, but work is progressing in this area (Brookshire and others 1979). If value functions are unavailable, the maximum and minimum bounds can be specified by inequality constraints. Algorithms to solve this class of control problems are available even under significant increases in the vector dimensions which would allow the interaction of several multiple uses of rangelands and a alternative control policies.

THE COSTS OF "GOVERNMENT FAILURE"

Government failure, as opposed to market failure, occurs when a government administered economic process fails to produce the socially optimal output or investment. The qualitative properties of the costs of regulated livestock production can be deduced by comparing the necessary conditions for optimum private production from rangeland with regulated production conditions.

Under private range management [equation (5)]--the biological dynamics obviously have to hold. The two control variables facing the rancher are current stocking rates and range improvement investments to make in a given year. Condition II becomes:

$$(9)\ \frac{\partial f_1(\cdot)}{\partial U^*_{1t}} + \gamma^*_{1t}\frac{\partial g_1(\cdot)}{\partial U^*_{1t}} + \gamma^*_{2t}\frac{\partial g_2(\cdot)}{\partial U^*_{1t}} = 0$$

$$(10)\ \frac{\partial f_1(\cdot)}{\partial U_{2t}} + \gamma^*_{3t}\frac{\partial g_3(\cdot)}{\partial U_{2t}} = 0$$

Equation (9) says that the rancher equates the immediate monetary benefits from increased stocking rates to the marginal value of the range biomass in the future, times the marginal physical effect of increased stocking on the biomass. That is, the marginal short-run benefits are equated to the marginal long-run opportunity costs. Note that γ^*_{1t} is not the same as γ_{1t} in equation (8), as under the institution of private rancher ownership $f_2(\cdot)$ does not enter the objective function. Given this assumption γ^*_{2t} will be zero for the rancher. Equation (10) states that at every instant the cost of investment in improvements must be equated to the marginal capital value of the improvements to the rancher.

Under an administered grazing system, the rancher is unable to rely on the capital value of future grazing. On a strictly annual permit basis, γ_1^* and γ_3^* would be zero, giving rise to the familiar problem of zero investment and overgrazing under open access.

A public administrator could plan to calculate what the optimum grazing level would be under equation (9) and set the permits at this level. Unfortunately, the problem is not static. While the administrator knows the immediate grazing returns to the rancher $\frac{\partial f_1(\cdot)}{\partial U_1}$ and the biological effects $\frac{\partial g_1(\cdot)}{\partial U_1}$, knowledge of γ_{1t}^* is much harder.

Equation (8) describes how γ_t^* the current marginal value of range biomass changes over time, (8) can be rewritten as:

$$(11)\quad \dot{\gamma}_1^* = r\,\gamma_{1t}^* - \gamma_{1t}\frac{\partial g_1(\cdot)}{\partial Y_1} - \gamma_{2t}\frac{\partial g_2(\cdot)}{\partial Y_1}$$

That is, in order to hold the capital asset of rangeland, the capital appreciation of rangeland must be equal to the opportunity cost of capital in the range less the imputed value of the biological growth that is made on the range in any given time period. Evidently, a range administrator would have to have accurate expectations of not only the range, but also the cattle cycle, the ranchers' opportunity cost of capital and the feed condition of the contiguous ranch property to closely approximate the economically optimum stocking rate. In short, the administrator would have to be a rancher.

Assuming, perhaps unfairly, that the administered stocking rate is held constant, a risk averse solution would be to maintain the stocking rate at the level that is justified by the lower third of the cattle cycle prices and below average range conditions. Given these constraints, ranchers would not be able to capture profits from upturns in the cattle cycle or range conditions and the costate on range biomass γ_{1t}^* would be zero. One cost component would be $\gamma_{1t}^*\frac{\partial g_1(\cdot)}{\partial U_{1t}^*} - \frac{\partial f_1(\cdot)}{\partial \bar{U}_{1t}}$ integrated over a specified time period, where $\bar{U}_{1t}$ the administered stocking rate may be above or below the optimum U_1^* depending on the cattle cycle and range conditions. The second cost of government failure is the social value of optimal increased production from rangeland improvements, equation (10) shows this to be $\gamma_{3t}^*\frac{\partial g_3(\cdot)}{\partial U_{2t}}$ integrated over the same period, for a single year an extreme case of government failure could cost

$$(12)\quad \int_0^1 \gamma_{1t}^*\frac{\partial g_1(\cdot)}{\partial U_{1t}^*} - \frac{\partial f_1(\cdot)}{\partial \bar{U}_{1t}} + \gamma_{3t}^*\frac{\partial g_3(\cdot)}{\partial U_{2t}}\,dt.$$

In practice the existence of ten-year leases, and some range inprovements would reduce this cost.

PRIVATE MARKET FAILURE COSTS

The costs to society of complete private ownership of the range are defined by deriving the conditions for the socially optimal multiple use management, and removing those collective goods that would not be supplied under a full set of private property rights. Given the Hamiltonian defined in equation (4) the necessary conditions are: Condition I unchanged, Condition II [equation (6)] is optimized with respect to the two control variables--stocking rate U_1 and hunting intensity U_3:

$$(13)\quad \frac{\partial f_1(\cdot)}{\partial U_{1t}} + \gamma_{1t}\frac{\partial g_1(\cdot)}{\partial U_{1t}} + \gamma_{2t}\frac{\partial g_2(\cdot)}{\partial U_{1t}} = 0$$

$$(14)\quad \frac{\partial f_2(\cdot)}{\partial U_{3t}} + \gamma_{2t}\frac{\partial g_2(\cdot)}{\partial U_{3t}} = 0$$

Equation (13) differs from the rancher's optimum (9) in two ways. First γ_{1t} will be larger than γ_{1t}^*. Since γ is the partial derivative of the objective function with respect to the state, additional value functions in the objective function related to Y_1 imply that $\gamma_{1t} > \gamma_{1t}^*$. In addition, the socially optimal solution values wildlife, so γ_2 is positive. The combined effect is to make the long-run costs of stocking rates higher. If U_1 is in the normal part of the production function, a reduction in private stocking rates will be needed to achieve the social economic optimum. The cost of private market failure over a unit time is the difference between the private value at the optimal private grazing level and the social value at the lower optimal level, plus the value gained from hunting access, which is assumed a fully collective good.

$$(15)\quad \int_0^1 \gamma_{1t}\frac{\partial g_1(\cdot)}{\partial U_{1t}} - \gamma_{1t}^*\frac{\partial g_1(\cdot)}{\partial U_{1t}^*} + \gamma_{2t}\frac{\partial g_2(\cdot)}{\partial U_{1t}}\,dt.$$

In the absence of the imputed value of wildlife through γ_{2t}, the increase in γ_1 over γ_1^* would more than compensate for the reduction in the marginal biological effect. This is because the social value function $f_2(\cdot)$ contains the range biomass stock as a direct argument. That is $\frac{\partial f_2(\cdot)}{\partial Y_1} > 0$.

It has already been argued that the choice of institutions is a discrete benefit/cost decision. Clearly, the costs of alternative institutions should be considered. However, given the theoretical basis of this paper, empirical measurement of the costs and benefits is beyond its scope. One additional qualitative conclusion can be drawn concerning the likelihood that demand developments favor the public or private property institutions for rangeland.

As a starting point, consider the costs of private and public institutions to be the same, and current costs of market and government failure on rangeland to be equal. Dramatic changes in the biological functional relationships through new technology or the profitability of ranching seem unlikely, therefore, changes in the cost of

private ownership (15) and public regulation (12) will occur through changes in the costates, (γ_t).

Condition III defines how the costate variables must change over time along the optimum path. The dynamic path of the three costates (or capital values) is:

$$(16)\quad \dot{\gamma}_1^* = r\,\gamma_{1t}^* - \gamma_{1t}\,\frac{\partial g_1(\cdot)}{dY_{1t}}$$

Smith and Martin (1972) find that nonmonetary outputs of ranch ownership are significant factors in explaining ranch sale prices in Arizona, but from a theoretical efficiency viewpoint the change in the private market costate for range biomass is shown by (16) to be proportional to the ranchers opportunity cost of capital.

The social rangeland biomass costate change is:

$$(17)\quad \dot{\gamma}_1 = r\,\gamma_{1t} - \frac{\partial f_1(\cdot)}{\partial Y_1} - \gamma_{1t}\,\frac{\partial g_1(\cdot)}{\partial Y_1} - \gamma_{2t}\,\frac{\partial g_2(\cdot)}{\partial Y_1}$$

and the wildlife costate is:

$$(18)\quad \dot{\gamma}_2 = r\,\gamma_{2t} - \frac{\partial f_2(\cdot)}{\partial Y_2} - \gamma_1\,\frac{\partial g_1(\cdot)}{\partial Y_2} - \gamma_2\,\frac{\partial g_2(\cdot)}{\partial Y_2}$$

Both these relationships are equilibrium path conditions which state that to be indifferent to holding capital in rangeland, the rangeland price must be such that the captial gains ($\dot{\gamma}$) must be equal to difference between the opportunity cost of holding rangeland ($r\gamma$) and the direct benefits $\frac{\partial f(\cdot)}{\partial Y}$ plus the value of productivity gains $\gamma\,\frac{\partial g(\cdot)}{\partial Y}$.

If the collective good demands that underly the $f_2(\cdot)$ function shift out over time due to population and income pressures (Clawson 1967), the costate values γ_2 and $\frac{\partial f_2(\cdot)}{\partial Y_2}$ will also increase. To return to the equilibrium path, $\dot{\gamma}_1$ and $\dot{\gamma}_2$ will correspondingly increase.

Given the relatively static expected profitability of range livestock operations, the faster time rates of change of the collective capital values of rangeland means that the costs of private market failure will increase relative to collective market failure over the forseeable future.

CONCLUSION

This paper has argued on the grounds of theoretical economic efficiency that several rangeland outputs have collective goods characteristics. This implies that a full set of private property rights is a necessary but not sufficient condition for their efficient production. Because the private and collective rangeland outputs have both stock and flow properties, market distortions occur in the differences between capital values.

A simplified capital model of multi-output range production was specified and the necessary conditions under two polar cases of private and public institutions are derived to show the qualitative properties of the costs of market and government failure. Obviously, there are ranges in which either cost could empirically dominate and indicate an optimum private or public set of property rights. An empirical test of the model seems feasible.

However, the qualitative properties of the changes in capital value over time will tend to increase the costs (to society) of private ownership and trends in this institutional direction should be approached with caution. A more desirable alternative similar to proposals by Gardner (1963) and others is for an institution of limited private grazing rights that contain sufficient capital incentives for investment in improvements and efficient cyclical stocking. Solution of an empirical capital model would allow calculation of the different levels of market distortion under alternative opportunity costs and marginal capital values.

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RANGE ECONOMICS IN THE BUREAU OF LAND MANAGEMENT

Judy Ellen Nelson

ABSTRACT: Major changes in the Bureau of Land Management's Rangeland Program put emphasis on economic analysis to increase the effectiveness of each program dollar spent. Economic screens focus the analysis effort and the internal rate of return is used as a tool to prioritize rangeland investments. A major grazing fee review and evaluation will provide the first comprehensive look at the value of public grazing lands since 1966.

INTRODUCTION

A year and a half ago, one of the more dramatic changes in Bureau policy in recent years occurred with the arrival of the Reagan Administration. Since then, Bureau personnel have been reorganized, budgets have been rearranged, and several programs--including range--have issued revised policy statements or regulations indicating a new program direction. Whether directly or indirectly, each of the changes that have and are occurring will influence range economics in the Bureau of Land Management (BLM). Within this same time period, the Bureau, together with the Forest Service, has begun a review and evaluation of the current grazing fee formula, as required by the Public Rangelands Improvement Act of 1978. One part of the grazing fee formula study is an appraisal of fair market rental values for public and private grazing lands in the Western United States. This appraisal is the most intensive collection of grazing value data since 1966.

RANGELAND MANAGEMENT POLICY CHANGES

Foremost in the Administration's efforts to improve the Federal Government are those aimed at increasing the effectiveness of each program dollar spent. Within the Bureau's rangeland management program, increased emphasis on cost-effective measures is most apparent in two recently released policy statements: a final grazing management policy and a draft rangeland improvement policy. Under the new grazing management policy, grazing allotments will be divided into three categories on the basis of their current resource situation and potential for resource and economic improvement. Lands with little potential for improvement, either because they are already producing near their high potential or because improvement is biologically or economically prohibitive, will be managed at the level needed to maintain current productivity. Most of our intensified funding and management efforts will focus on lands that are not producing near their potential and can be cost-effectively improved. New economic analysis procedures outlined in the draft rangeland improvement policy will help determine which allotments can produce the greatest return on the dollar and where the dollars should be invested first.

Rangeland Improvement Policy

The new economic analysis procedures were designed to both simplify our procedures and correct several weaknesses in existing analysis procedures. We appreciate the assistance of several members in the audience today. Fred Obermiller of Oregon State University chaired a special range economics task force appointed by Dave Tidwell, Special Assistant to the Director, to work with the BLM to develop realistic procedures. Other university professors who graciously invested their time and effort in this cooperative endeavor were Bill Champney of the University of Nevada, Bruce Godfrey of Utah State University, Jim Grey of New Mexico State University, Neil Rimbey of the Idaho State Extension Service, and Del Gardner of the University of California, Davis. A major objective of the special BLM-university task force was to design procedures that would bring the proposed range improvements in line with budget expectations while producing the greatest economic, social, and resource improvement per dollar expended. An additional sideboard on the procedures were that they could be understood and implemented by resource specialists and would not require economic expertise at the District level.

The Rangeland Improvement Policy first uses economics to help make a preliminary categorization of allotments, which begins very early in the planning process. Using available resource information and consultation with livestock operators and others, range conservationists estimate what types of improvements would be needed to eliminate existing resource use constraints. Anticipated benefits are compared with the probable costs of the improvements to determine the allotment's potential for positive economic return. Since one of the objectives of this early screening of allotments is to identify those where improvement efforts cannot be economically justified, range conservationists are asked to apply two common sense rules to their calculations: (1) Would the estimated improvements exceed the current selling price of private lands producing comparable forage? (2) Would the improvements cost more than the capitalized private grazing land lease rate, with an adjustment factor for non-livestock benefits?

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Economic screening of allotments becomes finer throughout the planning process as more information becomes available and the proposed improvement packages become more specific. Emphasis is placed on least-cost methods of achieving desired allotment objectives and on ranking the allotments for improvement. Benefit/cost analyses are performed for each improvement plan, or "management package." Generally, State or regional values for grazing, wildlife, and recreation are used to calculate benefits. More localized values may be used to calculate benefits when this information is available and documented. Costs are computed from recent improvement expenditures. Management plans that cannot pass a 1:1 benefit/cost screen at this point cannot be included in a final resource management plan unless justified by overriding social or resource considerations.

Allotment improvement packages are preliminarily ranked by their internal rate of return. District Managers can adjust these rankings, in consultation with District Grazing Advisory Boards, to meet special resource needs, social considerations or to improve implementation schedules. All reasons for adjustments in the ranking are to be recorded so that the process can be replicated if necessary.

The final economic screen occurs as part of the budget process. More resource information has become available and allotment improvement packages now include specific range improvement projects and better cost estimates. Additional economic information has become available through the concurrent planning and environmental impact statement processes. Examples of improved benefit/cost estimates may include seasonal forage values developed through ranch budget linear programming analysis, or hunter day estimates developed in consultation with State wildlife agencies. The improved estimates are again subject to economic analysis. Once again, allotment improvement packages are arrayed according to economic criteria, with adjustments allowed to meet resource and social considerations. These packages are scheduled for implementation on both a State and District level in conjunction with annual budget allocations to each State. Once again, all decision steps are fully documented.

One element of the economic analysis procedures that gave us the most difficulty (in terms of reaching a workable consensus) was the value to be assigned to nonmarket outputs. Several ways of valuing nonmarket benefits were examined. Assigning no value to these outputs and placing more emphasis on the political process was not selected because of the problems it would create in the budget justification process. Valuing nonmarket output at the opportunity cost of the livestock forage foregone to produce these benefits was examined, but discarded since an opportunity cost is not a true measure of value unless very rigorous conditions are met. The Forest Service's Resource Planning Act (RPA) values were chosen as the most acceptable values unless more local values are available.

A second element of debate was how to provide an incentive for private contributions toward rangeland improvements. The Department of the Interior's policy is to encourage contributions for range improvements as a way of stretching the Federal dollar. In the draft policy, the manager considers contributions as an additional factor influencing the final ranking. Whether this provides enough incentive for contributions is still a matter of debate. The concept of financing allotment improvements through matching Federal-private funding is currently being examined.

PLANNING AND ENVIRONMENTAL IMPACT STATEMENTS

The planning process has undergone a transition similar to the range program. Analysis for land-use plans and environmental impact statements is becoming less encyclopedic and much more focused on issues that have been identified through public participation at the local level. Economics is expected to play an earlier and increasingly important role in planning as a screening device to achieve maximum returns from Federal expenditures. The Washington Office will concentrate on providing analytical tools and standards, but will not mandate specific economic procedures.

We are in the process of developing two tools to aid field managers in analyzing the impacts of BLM's resource decisions on the ranching community. A ranch budget questionnaire has been prepared and approved by the Office of Management and Budget. This questionnaire has been widely distributed to obtain the professional evaluation of experts in the field and we hope to begin field testing the questionnaire soon.

We are also developing a user-friendly linear programming package. The program will allow users that are not computer experts to use the data gathered through the questionnaire to develop linear programming models. We will expect our field economists to solicit review of their models from local universities and other experts.

GRAZING FEE REVIEW AND EVALUATION

The Public Rangelands Improvement Act of 1978 established the current grazing fee formula for the Forest Service (FS) and BLM for the grazing years 1979 through 1985. Section 12b of the Act requires, "No later than December 31, 1985, the Secretaries (Department of Agriculture and Department of the Interior) shall report to the Congress . . . their evaluation of the fee established in Section 6 of this Act (the current formula) and other grazing fee options, and their recommendations to implement a grazing years." (Public Rangeland Improvement Act 1978)

The review and evaluation initiated by the Forest Service and the BLM in response to this charge has four tasks. The first is to evaluate the current fee formula; second, to establish fair market value (FMV) and the formula's closeness to this value; and, third, to evaluate other fee options. The final action is to recommend a fee schedule for 1986 and subsequent grazing years.

The review of the current fee formula began last year with an evaluation of the indices used to compute fees in the current formula. From December 1981 to February 1982, the U.S. Department of Agriculture's Statistical Reporting Service surveyed 12,000 ranching operations in portions of five Northern Great Plains States to check the validity of the forage value index. Preliminary analysis of the data collected show that factors such as landlord services, the length of the lease, size of operation, etc., significantly influence private grazing lease rates. We intend to perform further statistical analyses of the data to determine factor relationships.

Our preliminary analysis also showed that "average" private grazing lease rates are lower than the "reported" private rates. We obtain "reported" rates through the June Enumerative Survey, which is conducted annually to obtain leasing information needed to update the private grazing land lease rate used in the grazing fee formula. As a result of the preliminary analysis, this year's Survey of the 16 Western States included additional questions for measuring the consistency of the difference between reported and average rates and the validity of continued use of the June Enumerative Survey results in the grazing fee formula.

We are just beginning to develop methodologies for analyzing other grazing formula indices. The producers' price index will be reexamined, both in terms of the relevance of the cost of production items that were included and the possibility of developing regional indices. The data series used to compute the beef cattle price index is also being examined and compared with alternative data series.

Evaluation of the "fair market value" of Federal grazing lands will be one of the most difficult components of the grazing fee study. Fair market value was last established in 1966 after a survey of over 10,000 ranchers westwide. The BLM and the Forest Service have attempted to maintain a fair market value factor in the grazing fee formula by using indices to update the 1966 value. The accuracy of indexing, however, becomes increasingly suspect as the gap between the present and the time of the original survey widens. Consequently, one of the reasons that the current fee was established on a 7-year trial basis was to allow time for "the Secretaries to refine their data on the value of public grazing." (U.S. Congress, House, 1978) The BLM and the Forest Service have initiated a fair market rental value appraisal of public grazing lands in the West to accomplish this task. This is the first major data collection effort since the 1966 Western Livestock Survey. The appraisal is similar to the 1966 approach, which used a survey of western ranchers as a proxy for a comparative market value appraisal.

Agency appraisers will identify, locate, and obtain details of private grazing leases from both lessors and lessees. Information to be collected will include specifics of the lease, including such items as rental rates, length of the leases, rights and obligations of both lessor and lessee, season of use, periods of use, distance from lessee's base operation, private range use in conjunction with public lands, maintenance of range improvements, class and number of livestock, unit price, payment schedule, and a physical description of the land. Data on between 30,000 to 100,000 leases will be computerized. Although we will rely primarily on the professional expertise of our appraisers, the lease data will be subjected to a variety of statistical analysis procedures focusing on the determinants of grazing values.

The identification and evaluation of other fee systems as required by the PRIA will primarily center on grazing fee systems currently being used by State, local, and other Federal Government agencies in the Western United States. Colorado State University (with Tom Bartlett as principle investigator) was awarded a contract in February 1982 to identify, describe, and evaluate these grazing fee systems. The results of this study will also be used to help the BLM and Forest Service evaluate the administrative feasibility of the identified fee systems. Additionally, the identified fee systems will be measured against Congressional and Federal standards such as the stabilization and protection of the western livestock industry, equitability to grazing users and other users of the public rangelands, level of range improvements, rights and obligations of the parties, and levels of program expenditures and receipts.

The Forest Service and BLM will be working closely with the Economic Research Service in the development of representative western ranch budgets. These budgets will be formulated as linear programming models and will become the basis for assessing the impacts of changes in grazing fees on livestock operators. Shadow prices from these budgets will also be used to verify the appraisal values and may become the data used in a grazing fee option.

Concerns of the livestock industry, public interest groups, and other interested parties affected by or interested in this effort will be identified throughout the grazing fee review and evaluation. Ongoing public participation in informal discussions and briefings will advise the public about the status of the review and provide an

opportunity for them to share their ideas in resolving concerns, identifying alternative fee options, and developing final recommendations.

The agencies' goal is to have a final report for submission to Congress by December 1984. This will provide the Congress a full year prior to the 1986 grazing season to act on any recommended fee schedule.

RESEARCH NEEDS

I would like to conclude my speech with a few ideas about what I consider to be the major economic research needs in rangeland economics.

Demand analysis.--The grazing of livestock on public rangelands has been declining since records have been kept. Reasons for this decline, i.e., whether they be agency policies, a diminishing resource base, or a lessening demand for use or possession of grazing preferences, is uncertain. Continuation of declining demand for forage resources would have major policy implications for federal investment in public rangelands and in pricing decisions. The sensitivity of demand for grazing and other rangeland resources to pricing decisions needs to be addressed. This is a difficult problem because the impact of Federal prices on the private market must be determined. Arguments are made that the level of Federal grazing fees increases, decreases, or has no effect on observed private prices. We need theoretical and empirical research to resolve this debate.

Institutional Arrangements.--The Sagebrush Rebellion and the renewed call for private ownership of public lands have focused attention on the benefits and costs of alternative institutional arrangements. Many of the issues raised concern tenure rights to land use and how tenure influences investment and conservation decisions. Sound data for resolving these issues are lacking. What is needed is research on the best institutional arrangements or land management policies. With a shrinking public dollar devoted to range resources, policies that meet objectives with reduced Federal expenditures may become increasingly important.

Research in institutional arrangement, however, should not focus exclusively on the profit maximizing economic unit. Seventy-four percent of BLM permittees use less than 500 animal unit months (AUM's) annually: the average is 127 AUM's, or approximately 10 cows grazing a year. These figures raise the question of the appropriateness of treating the hobby rancher and the business rancher equally.

Nonmarket values.--Estimations of resource values, particularly the estimation of nonmarket values (including those associated with ranching), need to be improved before resource managers will have much confidence in their use in budget allocations. Especially important is the assurance that the measurement of values is consistent between resources so that nonmarket resources are not over or under valued in management decisions.

Much of the controversy surrounding ownership of the public ranges is an argument over the nonmarket values associated with the public range. As Gary Libecap (1981) argues, the "profit maximizing decisions of ranchers also maximize the net social value of rangeland and its contribution to production [and since] . . . there appear to be no significant external effects from private range use, ranchers (unlike bureaucrats) incur full social cost and benefits from their efforts." If this statement is true, few economists (or members of the general public) would argue with private ownership. But, as M. M. Kelso states in his article "Current Issues in Federal Land Management in the Western United States," written in 1947 (when there was "sharp and widespread conflict over the very existence of federal landownership in the West"):

> "When grazing is the only use on federal lands, it can be legitimately argued that, in line with long established national policy regarding agricultural land in the United States, it should be privately owned. But suppose this grazing use is only one of several uses on the same area, the others being watershed protection and water yield which are of equal or, what is frequently true, of greater value than grazing use?"

Kelso goes on to argue that one of the criteria for land remaining in public ownership is if the benefits of managing the land for multiple-use values (including the nonmarket commodities) are higher than the production lost in the private sector. We require much more knowledge of nonmarket range values before the benefits and cost of alternative ownership arrangements of public land can be fully examined.

Bioeconomic relationships.--William Martin (1972) states that "...agricultural economists finally quit most work on the (range economics) problem when it became evident that no consistent set of empirical data was available--or was likely to become available--with which to work." My recent review of rangeland literature has convinced me that the situation has not materially improved since Martin made the statement. I am also convinced, however, that the fault must be shared by economists who are unable to articulate what data is necessary to develop the bioeconomic models that could provide answers to important policy questions.

We need to design experiments that will develop resource/economic tradeoff functions. Economists must be willing to participate as members of interdisciplinary teams in designing experiments and monitoring the experiments if the end results are to have much utility.

In closing, what is lacking in rangeland economics research is the information needed to resolve basic policy questions and constantly recurring issues concerning public land management. To quote a remark made over 35 years ago" ... The most important place for study by western agricultural economists (is)...the make-up, organizational setting, and limits to the area of decision open to this agency ... if private uses of federal resources in the West is ever to be anything but a ceaseless bickering in the political arena."

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MULTILEVEL ANALYSIS OF FOREST AND RANGELAND RESOURCES

John G. Hof, Linda A. Joyce, Gregory S. Alward, and Thomas W. Hoekstra

ABSTRACT: This paper presents a multilevel analytical system for national-level forest and rangeland planning. This approach is a compromise between completely decentralized planning--where national plans would merely be summations of local plans--and centralized planning--where local output levels and budgets would be controlled by a national plan. The ecological analysis of resource production is developed at the most decentralized (local) level of planning. This provides the data base for local-level mathematical programming models of resource allocation. These, in turn, are used to generate management alternatives, characterized by an output set, that are used as choice variables in higher level mathematical programming models. The purpose of this system of models is to determine efficient production possibilities for the entire multilevel system. Because this system concentrates on efficiency considerations, a multilevel socioeconomic impact model structure is also described that would address equity-oriented considerations.

INTRODUCTION

In this paper, the central decision made through renewable resource planning is taken to be the selection of the output vector (mix) to be produced, and the determination of management actions necessary to produce it from the land base. In this context, the output mix includes land conditions as well as outputs that are removed from the land base. It is also assumed that the decision criteria in renewable resource planning fall into either efficiency criteria (e.g., costs and benefits) or equity criteria (e.g., socioeconomic impacts).

National renewable resource planning is a staggering problem because of conflicting needs for detail and scope. On the one hand, analyzing relatively small areas of land (such as a National Forest) is appealing because of the relative detail, resolution, and accuracy that can be achieved. On the other hand, concerns of regional and national scope may differ from local concerns, which increases the desirability of an analysis that can capture absolute and comparative advantages between smaller land units. Thus, local-level plans cannot simply be added up into a national plan.

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The ideal solution to this dilemma would be the use of a single national analysis that is capable of achieving high levels of resolution and detail. Because this is unworkable at this time, a multilevel modeling approach is suggested here. This approach attempts to incorporate national and regional discretionary control, a high degree of resolution and detail, and consistency between different levels of planning.

Work by Wong (1980) in the USDA Forest Service Southwestern Region provides an excellent start for the modeling approach discussed here. In general, he suggests that detailed production analysis should only be implemented at the lowest levels of the management organization, and that the regional- and national-level analyses should focus only on control through the selection of discrete management alternatives provided by the lowest levels of the organization.

Figure 1 depicts the key features of the proposed analytical approach. The "Primary Models" quantitatively describe the resource output responses to alternative land management prescriptions. The primary models for predicting range production responses are discussed further in Joyce (in press). The predictions from the primary models provide the data for the "Production Possibilities Generators" (PPG's), which are used, in turn, to construct discrete management alternatives for consideration at the regional/national level. Most logically, the PPG's would be mathematical programs that can generate "optimal" alternatives, given various objective functions and/or constraints. The regional/national-level models would also most logically be mathematical programs, as discussed further below. The multilevel system of mathematical programs is obviously oriented towards "efficiency" considerations. In order to incorporate "equity" considerations, a system of socioeconomic impact prediction models is also included, as shown in figure 1. The primary models, the multilevel optimization models, and the system of socioeconomic impact models are discussed in more detail below.

PRIMARY MODELS

Land management activities affect the structure and function of an ecosystem, and changes in the ecosystem are reflected in changing levels of resource outputs (fig. 2). Analytical techniques predicting single resource production quantify those pathways in figure 2 pertaining to the single resource, such as timber or wildlife. A consideration of the impact of this single resource management on other pathways and on the joint production of resource outputs is necessary to evaluate the total impact of management on

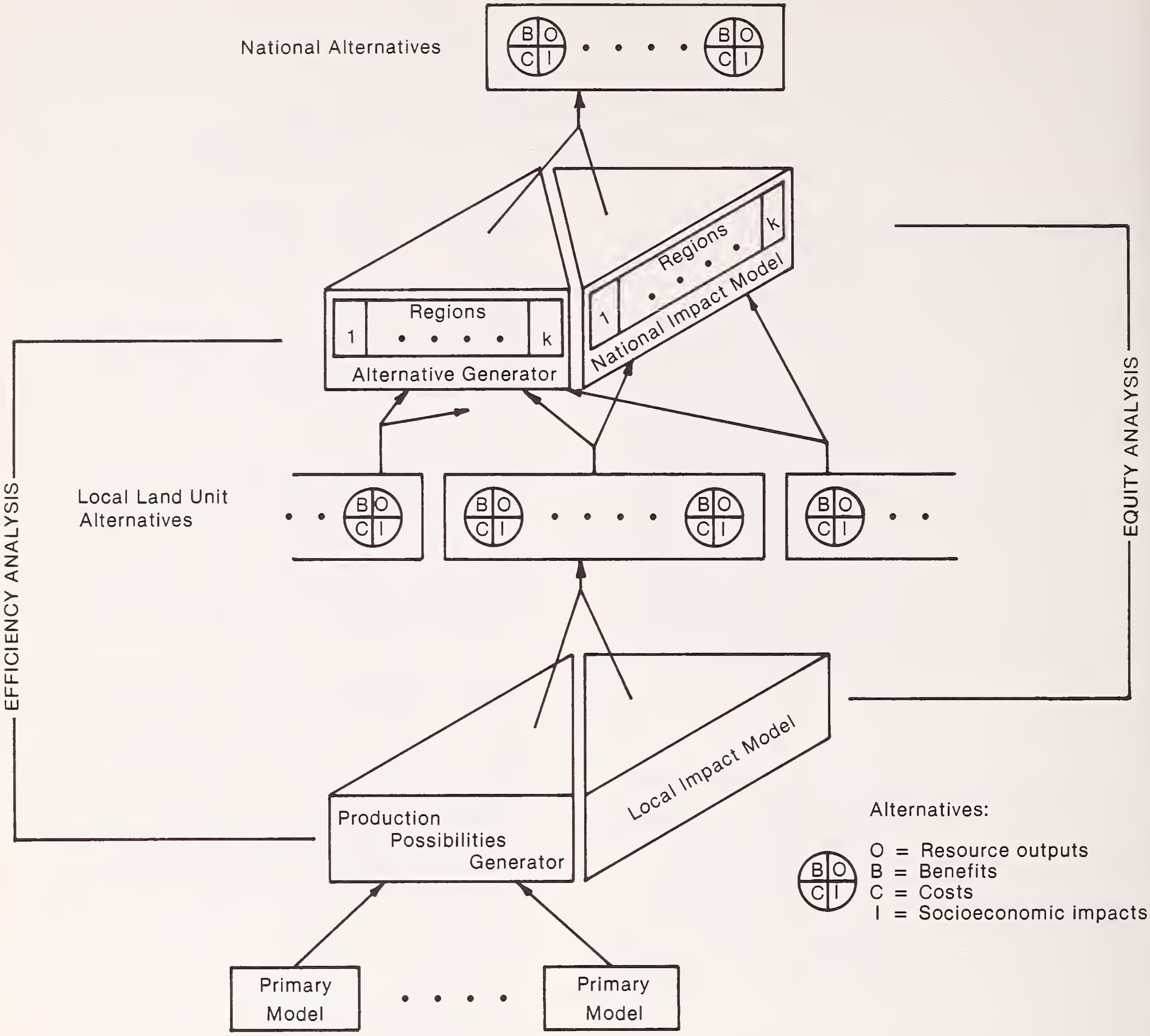

Figure 1.--Multilevel modeling structure for national-level planning analysis.

the ecosystem. This is the role of the primary models.

The three types of primary models are simulation models, statistical models, and models based upon intuitive approaches. The choice of the type of primary model is a function of the kind and amount of ecological theory and data available. A statistical model may be the best choice when there is sufficient empirical data to develop the required functions for joint resource production. A simulation model may be the best choice when the mechanisms related to the changes in resource outputs can be mathematically defined. Where little or no empirical data and only limited knowledge of mechanistic relationships exist, the model may be limited to an intuitive approach.

Simulation models.--These models represent an ecosystem as a collection of compartments that are linked by flows of materials, such as carbon or energy, contained in the compartments. The dynamics of the flows are defined by a set of rate equations representing known or postulated biological and physical mechanisms. The rates of flow can be a function of the levels of material in the compartments, or system-independent factors such as temperature and insolation. Simulation models are always constructed using simplifications of the real system. Manipulations of the completed

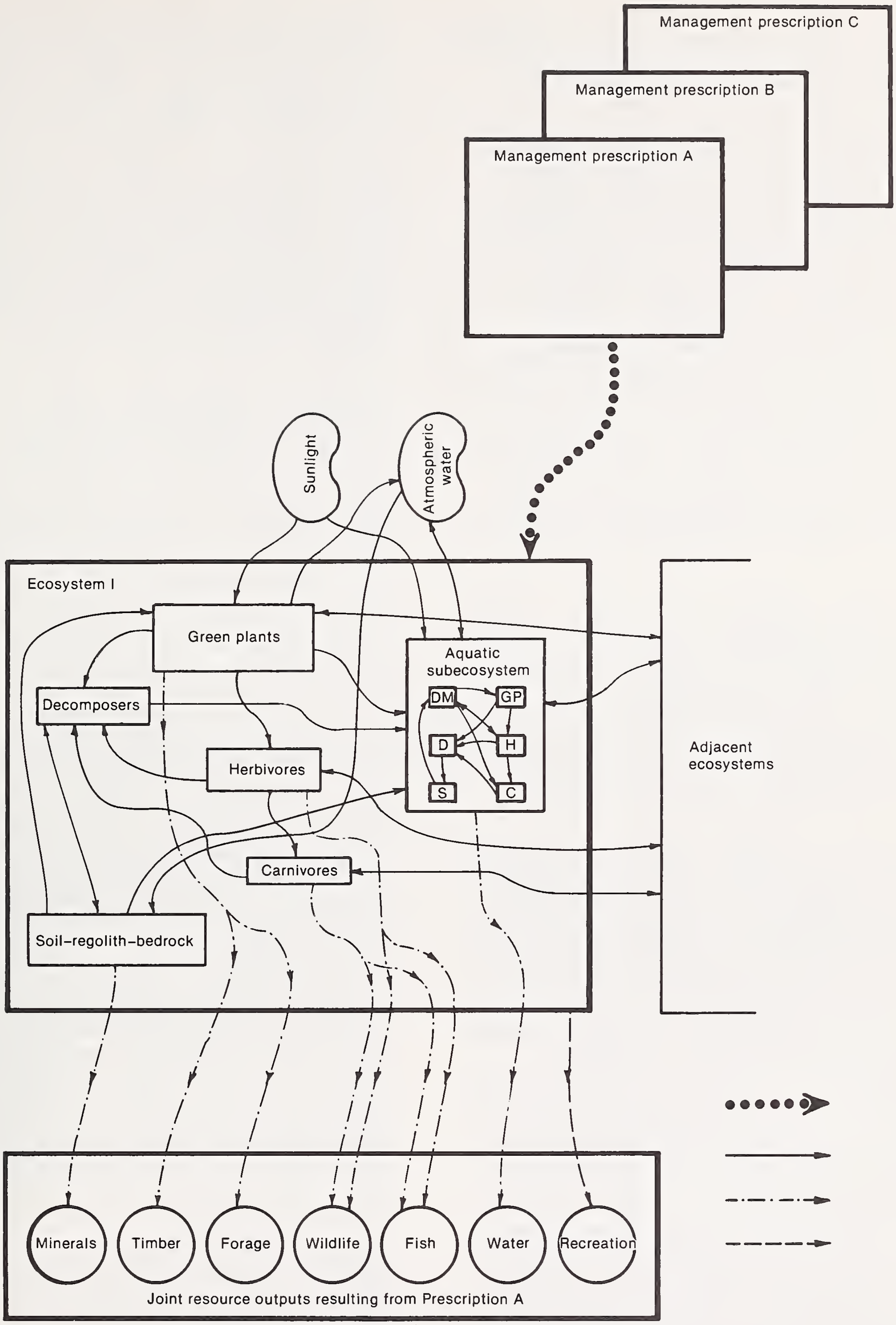

Figure 2.--Ecosystem structure and resource outputs. Management prescriptions applied to an ecosystem alter the array of simultaneously produced outputs by changing ecosystem structure and functioning.

ecosystem model represent the logical conclusions and extensions of our understanding of the ecosystem processes expressed in that model. Manipulations of the model help broaden our understanding of the mechanisms operating in the system.

Statistical models.--These models define empirical relationships between state variables or the compartments of the system. Techniques used to generate such models include multiple regression, time series analysis, and discriminant analysis. Often implicit in such models are assumptions about the functional form of the relationship between the variables. For example, a common assumption in regression analysis is that a dependent variable is a function of a linear combination of one or more independent variables. Except for models based upon time series analysis, most statistical models can provide only point estimates for state variables, i.e., the value of the variable at some fixed time. The accuracy of estimates from statistical models is related to both the validity of the assumptions used in the model, and the accuracy and number of observations that are used to estimate the parameters of the model.

Models based upon intuitive approaches.-- These models may be the acceptable alternative in those situations where theory and data are so sparse that neither simulation nor statistical models can be constructed. An intuitive approach, such as an interdisciplinary team approach, relies on experts to integrate their experience and the state of the art in estimating the point estimates or the functional relationships of the state variable response to various management prescriptions.

Within the analytical system, the results obtained from the primary models form a data base used in the PPG's. As primary models are the only level at which resource production information enters the modeling hierarchy, it is imperative that this information be organized in the most efficient manner and that it be as accurate and precise as possible. Primary models previously have focused on single resource production. Hence, the results from these single resource models require an integration process to form the multiresource data base for the PPG's. This integration process must standardize the primary model manipulations so that the same type of management activities are implemented in each primary model. The interdisciplinary team approach has served as a qualitative integration process. Future primary models for this analytical system may still focus on single resources but should contain a common description of each ecosystem studied, allowing for a more quantitative integration process. Developing primary models capable of simulating the simultaneous production of resources in any forest or range ecosystem is a research challenge.

MULTILEVEL OPTIMIZATION SYSTEM

A number of papers describe mathematical programming procedures that would be appropriate for the PPG's in figure 1. (See, for example, D'Aquino 1974; Johnson and others 1980; Ashton and others 1980; Kent 1980.) In application, both the PPG's and the higher level model(s) would most conveniently be linear programs, though this is by no means necessary. Each "alternative" generated by the PPG's is simply a vector of outputs that can be produced at an associated joint cost, a set of benefits, and a set of socioeconomic impacts.

Figure 3 depicts the linear programming matrix of a very simple version of a national model (Wong 1980). In this example, only two regions, two alternatives, and three products are included. Also, only one time period is included, and embellishments such as regional targets are not included. Expansion beyond the dimensions of this simple example is straightforward.

In figure 3, X_1 through X_4 are 0-1 variables representing selection or rejection of an alternative output vector with associated joint cost (F_i; i=1,4) for a given region. For example, X_1 represents selection or rejection of the entire output vector $A_{1,1}$; $A_{2,1}$; and $A_{3,1}$ in Region 1. Rows 5 through 7 set national "targets" on the three outputs (T, W, F). Row 4 places a budget constraint on the selection of alternatives, and row 8 is the objective function to be maximized. All of the matrix below the objective function row constrains the X_1 through X_4 so that each of them is between 0 and 1, and so that only one alternative can be selected for each region.

Because this is a linear programming model instead of a discrete optimization model, X_1 through X_4 may actually take on solution values between 0 and 1 but not equal to either. For example, X_1 and X_2 in figure 3 may solve with values of 0.6 and 0.4, respectively. This is interpreted as a partial acceptance of each alternative, the combination of which satisfies the "0-1 model constraints." This may suggest the construction of a new alternative that is subjectively constructed from X_1 and X_2, based on the solution values. Some means, such as re-solving the lower level model, would be needed to determine the cost and feasibility of the new alternative. No assurance can be made that this new alternative will be completely accepted in the national model. Its presence may actually cause changes in the solution values of any or all other variables as well. Resolution of this problem is an important research need in the development of the multilevel analytical system. The use of zero-one programming would avoid this problem, but the partial acceptance of alternatives may prove to be valuable information.

Consider the case where a continuous linear programming model indicates partial selection of a plan for a particular region. This would indicate that no single alternative at the regional level optimally met the national objectives but that a partial selection of plans did. This provides important information to planners at both levels. Two situations can occur in the higher level model that will cause partial selections. First, there may be no combination of complete regional alternatives that meet the national output targets; however, partial selections do. Second, while a combination of complete regional alternatives might meet the national targets, a

	Region 1		Region 2		Outputs			Type	RHS
	X_1	X_2	X_3	X_4	T	W	F		
Timber	$A_{1,1}$	$A_{1,2}$	$A_{1,3}$	$A_{1,4}$	-1			=	$0=K_1$
Wildlife	$A_{2,1}$	$A_{2,2}$	$A_{2,3}$	$A_{2,4}$		-1		=	$0=K_2$
Forage	$A_{3,1}$	$A_{3,2}$	$A_{3,3}$	$A_{3,4}$			-1	=	$0=K_3$
Budget	C_1	C_2	C_3	C_4				$\leq$	K_4
					1			$\geq$	K_5
						1		$\geq$	K_6
							1	$\geq$	K_7
Obj. Fun.	$-F_1$	$-F_2$	$-F_3$	$-F_4$	F_5	F_6	F_7	-	MAX
0-1	1	1						=	1
Model constraints			1	1				=	1

Figure 3.--A simple national model, where the X_1 through X_4 are 0-1 variables representing selection or rejection of an output vector $A_{i,1}$ through $A_{i,4}$ (i=1,3), respectively. The F_j are the objective function coefficients, and the K_1 through K_7 are right-hand sides (RHS).

partial selection(s) might exist that results in a higher present net worth (maximizes the objective function to a higher degree). Consider solving the same problem with zero-one programming. In the first case, an infeasible solution would result, indicating that a new alternative(s) is needed. However, in this case, no information on the nature of that new alternative would be supplied to the analyst. In the second case, one alternative would be selected for each region and a feasible solution obtained, but the solution would result in a lower present net worth than if partial selections were permitted. The zero-one programming approach does not indicate that better regional alternatives may exist.

The principal advantages of a multilevel optimization such as this, is that the detail and high resolution of local-level analyses are preserved, but national discretionary control is still allowed--the national plan will not simply be a summation of local plans. The implied national model reflects a great deal of detailed production analysis, but is itself of very workable size and complexity. And, any national model solution is automatically disaggregatable to (and consistent with) local management plans. The principal shortcoming of a multilevel optimization approach is that limiting the national analysis to a finite number of discrete choices may overlook desirable options and thus lead to suboptimization.

SOCIOECONOMIC IMPACT SYSTEM

The preceding discussion has emphasized the concern for being efficient regarding the costs incurred to productively manage forests and rangelands. In general, the costs of delivering goods and services from forests and rangelands to ultimate consumers are affected by the location of these management activities, which are captured by the multilevel optimization system described above. Beyond this, however, planning criteria may extend beyond pure "efficiency" concerns to matters involving the utilization of labor and industrial capacity, and to the manner in which benefits and costs are distributed among members of society. Thus an "equity" or "distributional" analysis confronts such issues as: estimating how a management program might affect regional unemployment or idle industrial capacity; the dependency of communities on programs or their vulnerability to program changes; the generation and distribution of regional income; and the extent to which resource management programs could be used as positive tools of regional economic policy.

To determine the distribution of the economic effects of forest management programs both regionally and among participants, a framework of structural models of economic activity is recommended here. A system, referred to as IMPLAN,

has been developed (Alward and Palmer, in press) to derive regional input-output models for the local areas affected by Forest Service programs. As illustrated in figure 1, impact models are used to estimate the socioeconomic effects of management alternatives at both the local land unit level (local impacts) and at the regional/national level (regional/national impacts). Since all impact models are constructed in the same manner from an internally consistent data base, the socioeconomic impact system produces a multilevel hierarchy of impact estimates. With these structural models, the distributional consequences of new or modified management programs can be traced in terms of income gains (losses) to industries and labor. Special attention is given to estimating employment effects by tracing impacts upon unemployed workers, occupational categories, and income groups, and the implications of these effects in terms of the issues noted above.

The general form of a regional impact model is given in equation [1]:[1]

$$\underline{X} = (C\underline{Y}^1) + (C\underline{Y}^2) + \cdot \cdot \cdot + (C\underline{Y}^m) \qquad [1]$$

The vector of gross outputs by sector for the region ($\underline{X}$) are determined from direct and induced changes in regional final demands ($\underline{Y}^n$, n=1, m) by applying the matrix of total requirements (C). This "open" matrix does not include the household industry. Induced changes in regional final demands ($\underline{Y}^n$, n=2, m), which arise from consumptive spending of household income, are determined iteratively as a function of regional income, as shown in equation [2]:

$$\underline{Y}^n(n=2,\ m) = f(\underline{I}_r^n,\ n=1,\ m-1), \qquad [2]$$

The function (f) specifies the resident populations propensity to consume locally produced outputs. The total effects of induced spending are captured when the estimated changes in gross output approach zero, as in equation [3]:

$$|\ (C\underline{Y}^m)\ | \longrightarrow 0 \qquad [3]$$

Direct changes in regional final demands ($\underline{Y}^1$) are estimated from changes in output production, resource uses, and government purchases associated with a management program as determined by the multilevel optimization system. Equation [4] provides the identity for changes in direct final demands as a function of timber harvest (T), forage grazing (G), mineral, oil, and gas extraction (M), water flow (W), recreation use (R), and government purchase (E):

$$\underline{Y}^1 = g(T,\ G,\ M,\ W,\ R,\ E) \qquad [4]$$

Regional employment ($\underline{L}$) is determined from changes in gross output, as shown in equation [5]:

$$\underline{L} = h(C\underline{Y}^n,\ n=1,\ m) \qquad [5]$$

The function (h) accounts for employment drawn from the regional unemployment pool and in-migration induced by employment opportunities. The employment effects can likewise be expanded to include occupational categories and income groups. Regional income from employee compensation ($\underline{I}_c$) is estimated from the predicted employment effects, as given by equation [6]:

$$\underline{I}_c = i(\underline{L}) \qquad [6]$$

Equation [7] shows that regional income from property ($\underline{I}_p$) is a function of gross output:

$$\underline{I}_p = j(\underline{X}) \qquad [7]$$

Total regional income is the sum of employee compensation and property-type income.

As can be deduced from the equations above, applications of the model to estimate regional economic impacts are conducted independently for each study area (e.g., for a local economy affected by a National Forest's program). Significant leakages via import and export flows are characteristic of such areas. These flows represent the interdependencies between regional economies represented by such factors as trading patterns and commuting behavior. To incorporate these aspects, the methods for constructing impact models are being expanded to obtain interregional input-output formulations. This enhancement will permit a more complete tie between the estimation of regional economic impacts and locational shifts in resource production or use investigated by the multilevel optimization system. Futhermore, the explicit incorporation of interregional feedback flows between regions gives a comprehensive estimate of local effects. On the basis of this information, the potential to discern the social consequences of resource management programs is enhanced.

CONCLUSION

Previous national planning analyses have tended to analyze one resource at a time and have tended to be predictive. One important exception was the NIMRUM effort attempted in the 1980 USDA Forest Service RPA Assessment Analysis of "Multiresource Use Interactions" (Ashton and others 1980). The multilevel analytical system could be regarded as an extension or development of this effort--an extension oriented toward simplification and increased workability. It leaves the detailed problems of land allocation and management practice scheduling to the lowest land unit level of analysis. At the regional and national levels, the point of focus is the problem of selecting the output mix. By limiting the regional and national analyses to this problem, the models at all levels are reduced to workable size and complexity, yet a considerable degree of discretionary control at the higher levels of analysis

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[1]Matrices and vectors are denoted by capital letters, with vectors distinguished by underscoring (e.g., $\underline{Y}$); superscripts indicate computational iterations.

is preserved. The principal shortcoming of the multilevel optimization system is that limiting the choice variables at the regional and national levels to selection from a finite number of alternatives may cause the analysis to overlook desirable options that are, in fact, feasible.

In limiting most of the production possibilities analysis to the lowest level of analysis, some interaction effects between land units may be ignored. Examples of these effects are (1) enhanced migratory bird populations resulting from coordinated habitat management on a given flyway and (2) downstream water quality effects resulting from timber harvesting. Nonetheless, the multilevel system solves the problem of disaggregating national analysis results across smaller land units, and it avoids problems of inconsistency between levels of analysis that would occur if these analyses were performed independently.

Finally, this paper has discussed a general modeling approach. It should be noted that an application of this approach has been proposed as part of the 1989 Assessment of Forest and Rangeland Resources carried out by the USDA Forest Service, mandated by the Resources Planning Act (RPA) of 1974. This application will concentrate on multiresource interactions considerations in identifying opportunities for improving the future renewable resource situation. It is currently being referred to as a "National Assessment Multiresource Model" (NAMM), and is viewed as an augmentation of the more functional, predictive analyses that have traditionally been (and will continue to be) included in national assessments of forest and rangeland resources.

A modeling approach that is similar to that described here is being developed for the 1985 RPA Forest Service Program. This effort will utilize the FORPLAN models being built for use in Forest-level Land Management Planning as the lower level models. The higher level model is the ADVENT budgeting model. IMPLAN models will be used at the forest, regional, and national levels.

Since NAMM will be used in the 1989 Assessment, it must account for all forest and rangelands, not just the National Forest System. Also, while the emphasis in ADVENT is on solving a budgeting problem, the emphasis in NAMM will be on analysis of production potentials, resource allocation, and economic efficiency. It is anticipated that NAMM might be linked to the 1990 Program budget analysis to improve the allocative efficiency of the 1990 Program.

As in the 1985 ADVENT model, it is anticipated that NAMM will utilize FORPLAN-generated alternatives for National Forest System lands. For other forest and rangelands, it is anticipated that one linear program will be built for each Forest System Region to generate alternatives. Since these lands are not under direct Forest Service control, only low-resolution management opportunities need be identified. It is likely that the NIMRUM software, developed for the 1980 RPA Assessment, will be used for these regional linear programs.

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MULTIRESOURCE PRODUCTION AT THE REGIONAL LEVEL

Linda A. Joyce*

ABSTRACT: This paper presents a modeling approach to analyzing the multiresource production response to alternative management activities used in national assessments of forest and range resources. Primary models are developed in a framework that integrates the current strengths in single resource modeling efforts.

INTRODUCTION

The Forest and Rangeland Renewable Resource Planning Act (RPA), as amended by the National Forest Management Act, requires the USDA Forest Service to assess the current and future production of all forest and range land resources. Assessing the range resource at the national level requires an approach which is capable of assessing the future range production on all forest and range lands, which is repeatable, and which accounts for interactions with other resources. This paper presents a modeling approach in which single resource models are integrated to represent multiresource production at the local level. These primary models are used together to develop the management alternatives to be analyzed at the national level. While demand information is also required in the assessment, this paper discusses only the models analyzing multiresource production.

BACKGROUND

The tasks specified in the RPA have been interpreted by Hoekstra and Hof[1] to require:

1. Current and historical inventory information on natural resources;

2. Future projections of current production and consumption patterns;

3. Opportunities for improving the future resource production situation, considering tradeoffs in production for all renewable resources.

Analyzing opportunities for improving future resource production requires a methodology capable of analyzing different alternatives for forest and range land management, under varying decision criteria. Such a model at the national level could examine the tradeoffs in production of all renewable resources.

In the 1980 Assessment (USFS 1980), the multiresource analysis of future opportunities was facilitated by the development of a large linear programming model, referred to as NIMRUM (Ashton et al. 1980). This linear programming (LP) model allocated acres of land in the entire forest and range land base by ownership to different management strategies based on the decision criteria of minimum cost.

Current resource management, multiresource outputs, and costs of production were estimated by regional interdisciplinary teams, using a set of procedural guidelines.[2] These current management activities formed the columns of the A-matrix in NIMRUM. Future resource demand information was supplied to the model. The NIMRUM model then allocated management activities to the entire forest and range land base in a way that the cost of management was minimized. The result of this analysis was one management alternative, composed of a set of management activities for units of land within the forest and range land base. This alternative suggested one strategy for improving resource production.

Within NIMRUM, the land base was divided into resource units on the basis of vegetation-ownership-condition-productivity classes. Kuchler's (1964) 107 Potential Natural Vegetation Communities were used. Ownership categories were: National Forest System (NFS) lands, Bureau of Land Management lands, other Federal lands, and State and Private lands. Four condition and four productivity classes were used. Current management was classified by the timber-range-wildlife strategies, of which there were 126 strategies possible. Because more than one management strategy could be currently used in each resource unit, the size of the NIMRUM model was large.

Two criticisms can be made of this model. One is the large size which limits the number of times the model can be run. The other concerns the subjective nature of the data base. The use of interdisciplinary teams may be the only alternative to generate such a data base; however, this method is subjective and the information is not easily updated.

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[1]Hoekstra, Thomas W., and John G. Hof. 1982. Technical Requirements for National Assessment of Wildlife and Fish. RPA Assessment Staff Paper. February 15, 1982.

[2]USDA Forest Service. 1977. Book of Procedures Framework for Supply Analyses. Mimeo. Washington, D.C. 100 p.

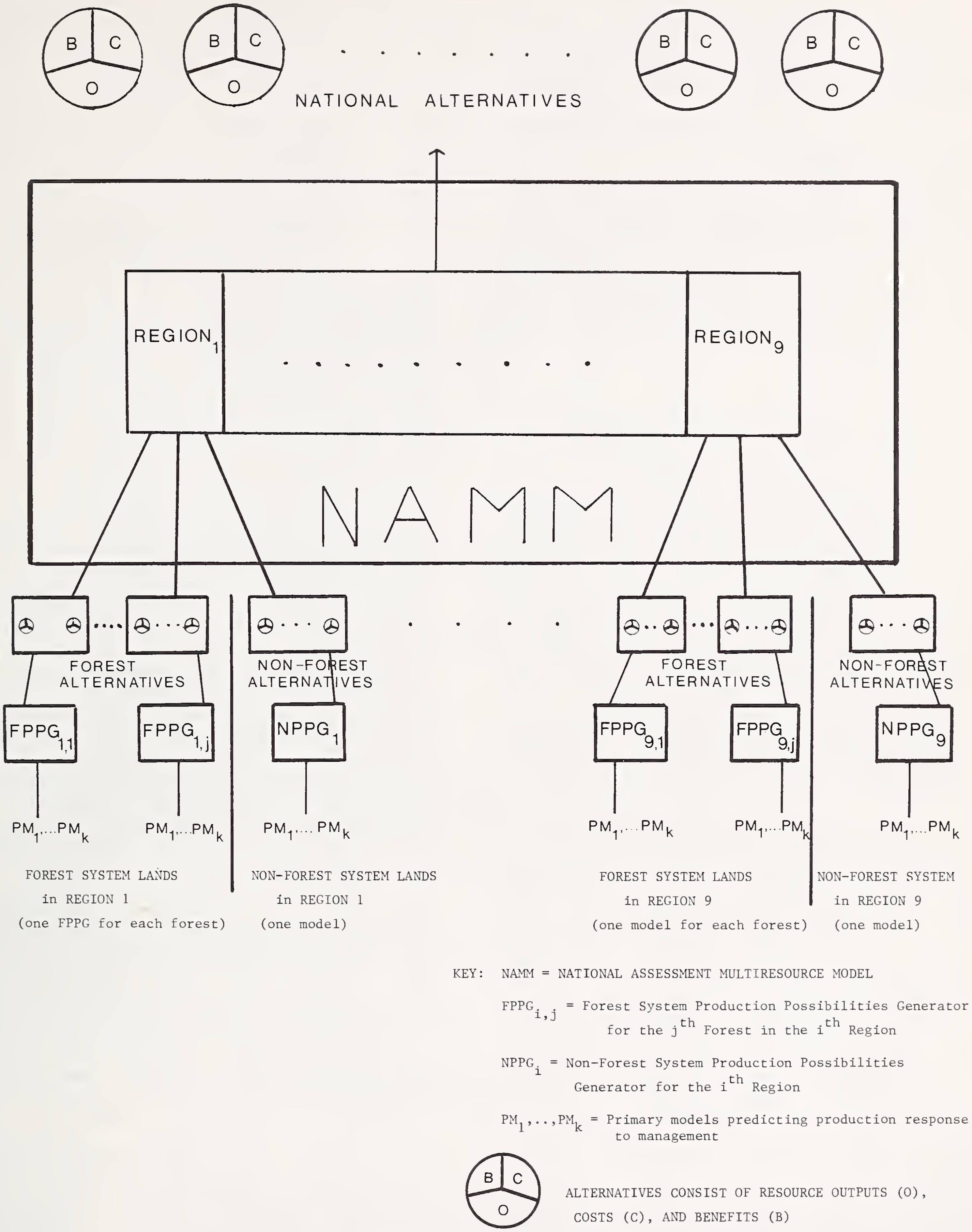

Figure 1. The multilevel analytical system.

Hof et al. 1982, in this symposium, proposed a multilevel analytical system for national level forest and range land planning (fig. 1). Within this hierarchy, regional/national level models allocate land management alternatives to ownerships. Because these models do not allocate management activities to acres of land, these models are small, and can be rerun quickly and efficiently. The local level LP models, referred to as Production Possibility Generators (PPG), allocate management activities to acres, and, consequently, are more detailed. Primary models develop the resource response information needed in the PPG's. Because primary models are the

only level at which resource production information enters the modeling hierarchy, it is imperative that this information be organized in the most efficient manner and that it be as accurate and precise as possible. This paper addresses the development of these models.

MULTIRESOURCE PRODUCTION

The LP model, referred to as Production Possibility Generator (PPG) in the multilevel system (fig. 1), can be solved to give the optimal set of management activities to be used in a particular land unit based on a particular objective, such as economic efficiency. The optimal set of management activities constitutes one management alternative for either the NFS land unit or the non-NFS land unit.

The multilevel analytical system is designed to receive input from the established National Forest System Planning Process. An example of a FPPG is FORPLAN, the LP model constructed by interdisciplinary teams as part of the forest planning process on each National Forest. FORPLAN is used to select a set of management activities for the entire National Forest, which are optimal in terms of some decision criteria. This set is called a forest-wide plan. Alternative forest-wide plans are selected by using alternative decision criteria, inputs (such as budget levels) or constraints in the FORPLAN model. For each forest-wide plan, the model provides a summary of costs, benefits, and outputs.

The established NFS Planning Process facilitates the development of primary models and the PPG for NFS lands. There is no similar process for non-NFS lands.

Non-NFS lands are under diverse managements, and future alternatives for these lands can be defined only by general assumptions. An example of a PPG would be a regionalized version of the NIMRUM model. The original model focused on the entire forest and range land base. This regional model would be used to select a set of management activities for the entire non-NFS land base within the region. This set could be called a regional plan for non-NFS lands. Alternative regional plans could be selected by using alternative decision criteria, inputs or constraints in the model. This production information on non-NFS lands could be used to define general opportunities rather than specifying precise management. For each regional non-NFS plan, the model would provide a summary of costs, benefits, and outputs.

These PPG's still require resource production information. Each column in the A-matrix represents the joint production of resources in response to the associated management activity. Therefore, the procedure used to develop this information must simulate the joint production of multiple natural resources.

The methods that have been developed to estimate the joint production of natural resources can be categorized as follows:

1. Interdisciplinary (ID) Team Approach. This approach uses the experience of each team member to predict the joint production of natural resources in response to management.

2. Multiresource Models. This approach attempts to aggregate functional models.

3. Joint Production Models. This approach attempts, in one model, to predict the simultaneous production of natural resources in response to management.

The ID team approach has been used by the Forest Service in its forest level planning process (Forest Service Planning Handbook FSM 1920) and in previous Assessments. It has been used by private corporations (Cooper and Zedler 1980), and by governmental and private groups together (Holling 1978). This approach, however, offers no way to update the production estimates other than going through the ID team exercise again.

The multiresource modeling approach attempts to aggregate single resource models. This approach to modeling ecosystem dynamics has been successful in several areas. Sullivan et al. (1981) adapted a forage model of a subterranean clover pasture in Western Australia and the Texas A&M Cattle Production System model for tropical conditions in East Africa. Eraslan et al. (1976) combined a hydrodynamic model of heat and salt transport with a population model of striped bass. In a large modeling project, five models were aggregated to simulate shortgrass prairie dynamics (Innis 1978). Sullivan et al. (1981) and Eraslan et al. (1976) aggregated models that were previously developed. In Innis (1978), the scientists building the models worked together initially to devise a set of common state variables to connect the models, and then constructed the models independently.

Analysis of joint production using ecosystem structure and function, the third approach, is a recent development. Progress in this area has been hampered by insufficient and inadequate data, and by lack of ecological theory. Long-term records of ecosystem response to management under controlled conditions are rare. Advances in ecological theory continue to be made, but, as yet, there is no single unifying theory about ecosystem structure and function that could be applied to all ecosystems (Joyce et al. 1982).

Multiresource models offer the most promising approach to the estimation of forest and rangeland outputs. Quantitative techniques predicting the production of natural resources have thus far focused on single resource outputs. These techniques in three functional areas have been reviewed by Alig et al. (1982) for timber, Hawkes et al. (1982) for wildlife and fish, and Mitchell (1982) for range. Within this multiresource modeling approach, research and existing data within the individual resource areas could be drawn upon to select and/or develop functional models.

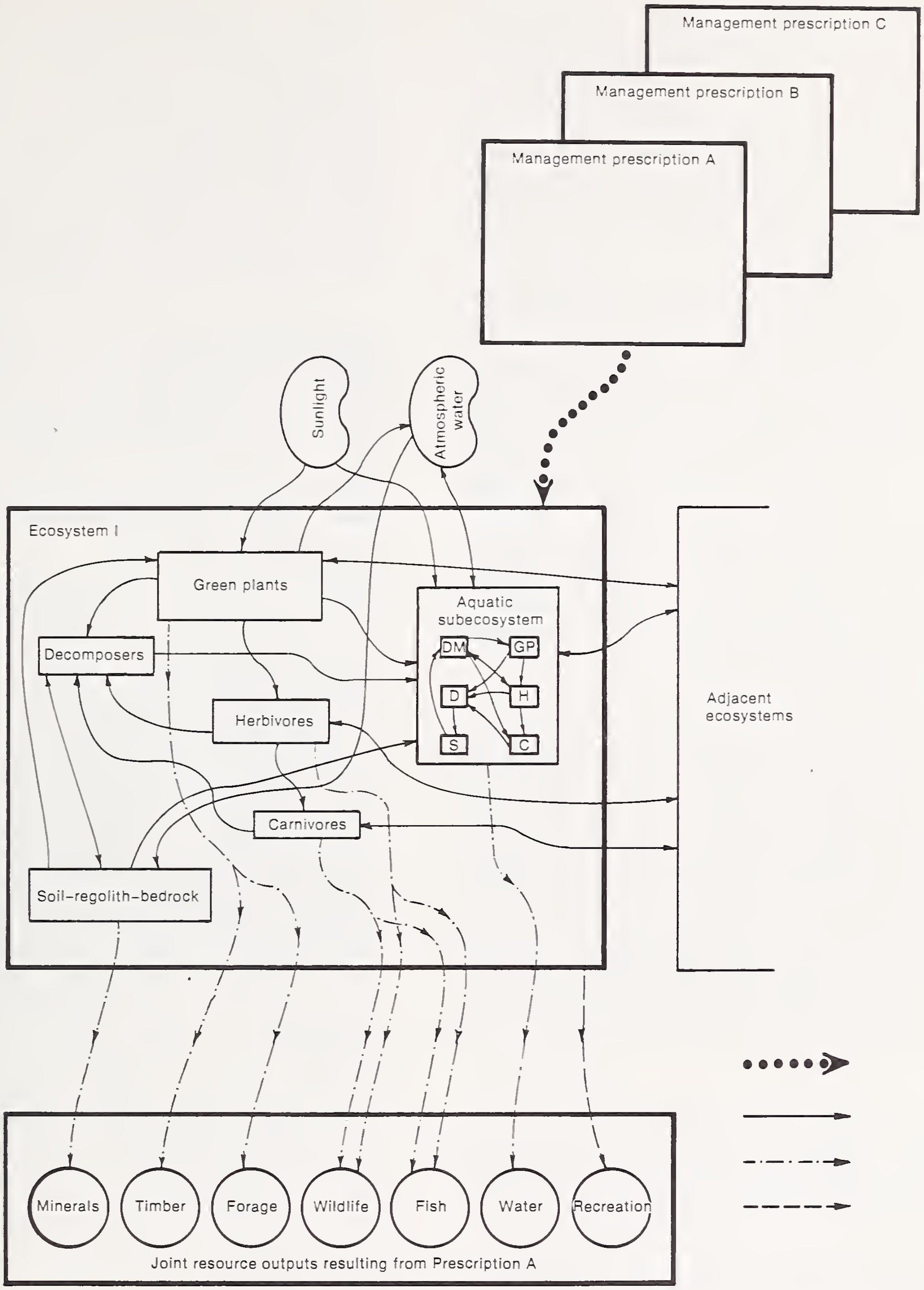

Figure 2. Management prescriptions, ecosystem structure, and resource outputs.

REGIONAL MULTIRESOURCE MODELS

The proposed framework addresses the development of primary models for non-NFS lands in each NFS region. These primary models would together estimate the multiresource response to management activities on non-NFS lands. This data forms the A-matrix of the PPG for non-NFS lands. Each regional plan generated in the PPG is to be used as a choice variable in the higher level LP models in the multilevel analytical system. At the national level, alternative management plans for NFS lands and non-NFS lands are analyzed together with a multilevel system.

Primary Models

The purpose of a primary model is to describe quantitatively an understanding of the impact of management on the ecosystem at the National Forest level in the forest planning process, or at the regional level for non-NFS lands in an assessment. Land management activities affect the structure and function of an ecosystem, and changes in the ecosystem are reflected in changing levels of resource outputs (fig. 2). Models predicting single resource production quantify those pathways in figure 2 pertaining to the single resource, such as timber or wildlife. A

consideration of the impact of this single resource management on other pathways, and the joint production of resource outputs is necessary to evaluate the total impact of management on the ecosystem. This is the role of the primary models.

Primary models are required to generate input to the LP models. An LP analysis implies certain assumptions about the data use in the LP model. Primary models must be constructed with these assumptions clearly stated.

The three types of primary models are simulation models, statistical models, and models based upon intuitive approaches. The choice of the type of primary model is a function of the kind and amount of ecological information and theory available. A statistical model may be the best choice when there is sufficient empirical data to derive the required functions for the joint production of resources. A simulation model may be the best choice when one can define mechanisms related to the changes in the state variables of the system, and when sufficient data exists for validation of the model. Where little or no empirical data and only limited knowledge of mechanistic relationships exist, the model may be limited to one based upon an intuitive approach.

Standard Protocol

The process of creating the primary models in the multiresource modeling approach would be facilitated by a standard approach across regions. This protocol would assure that the primary models were the best models that could be constructed to estimate multiresource production and provide the most appropriate input to the LP models.

Within each region, a multiresource framework would be used by an interdisciplinary team to facilitate selection and/or development of single resource models. The development of the single resource models would be the responsibility of each resource specialist.

Six steps outline a standard approach:

(1) Each resource specialist on the ID team defines the set of resource outputs and management prescriptions to be considered at the regional level.

(2) Each resource specialist on the ID team defines the variables from other resources needed to predict their own resource.

(3) The ID team defines the set of resource outputs and management activities to be considered in the multiresource framework.

(4) Each resource specialist chooses the type of model to be built or selected in each functional area.

(5) Each resource specialist constructs and documents the single resource models.

(6) The adequacy of each model is tested.

Steps 1 and 2 are important in quantifying this process. The many problems associated with integrating primary models for different resources can be avoided or simplified if the primary models define relationships between components of the natural resource system which contain, at any time, measureable quantities. These components are usually called state variables. They include such examples as the biomass of shrubs, or the concentration of sediments in stream water. Determining the set of management activities to be examined defines the minimum number of variables within the primary models.

Steps 1 and 2 represent an "inward" and "outward" looking approach to model building. In step 1, the resource specialist defines variables to be used to estimate the regional production of their resource. Step 2 is an approach used in Holling's environmental assessment workshops, referred to as "looking outward." This step forces the resource specialist to examine those outside factors that affect the individual resource.

Step 3 represents the consensus across resource areas. Resource interactions vary by the combination of resources considered, the land unit being analyzed, and the spatial and temporal patterning of management within the land unit. Because primary models form the data base for LP models, the assumptions about input data in LP models must be considered. Most commonly, LP models presume production coefficients on a per acre basis, and no interaction between acres. Resource interaction on a per acre basis can be analyzed only for those resources produced on a per acre basis, such as timber and range. Interactions between timber, range, and water require the description of the spatial and temporal patterning of management within a land unit, such as a watershed. Wildlife production may be a function of the temporal and spatial patterning of management across more than one watershed.

Once the resource outputs and mangement activities have been defined, the state variables which must be included in the multiresource models can be defined. If a management activity is to be considered, the variables in the ecosystem which are affected by that activity must be included in the models. Models draw logical consequences only of what was put into them. Step 3 involves a consensus among the resource specialists on these concerns.

Step 4 represents an evaluation by each resource specialist of the types of single resource models. This step is important within each functional area in defining a rigorous approach to quantitatively predict the resource output. This step is important across functional areas in defining a common framework, so that the inputs to these models and the outputs from these models can be used to determine multiresource production in response to management.

In general, simulation models often require more information about the system and data than

statistical models. This information usually consists of quantitative statements about mechanistic relationships and some data which can be used to validate the model. Statistical models, in contrast, require little or no information about mechanistic relationships, but require quantitative data of sufficient quantity and quality to permit statistical relationships to be derived. The intuitive models should be used only where data sufficient to construct either simulation or statistical models are lacking. Two criteria by which to compare alternative models are the amount of uncertainty in their predictions and the accuracy of the predictions.

If possible, extant models should be used. If not possible, then the resource specialist must select a technique to build the model. It is not anticipated that the models in all resource areas would be similar in terms of methodology.

In step 5, the construction of the models would include the model development and the conversion of those models into computer algorithms. The importance of model documentation must be stressed. Documentation provides the mechanism by which models can be efficiently modified and improved.

The exact nature of step 6 is dependent upon the type of model and the original objective for the model. Primary models need to represent the responses of the system to management prescriptions in an acceptable manner. Validation is a procedure by which the responses of the primary models are compared to the responses of the natural resource system under similar conditions. In this analysis, the purpose of the model must be defined, because the criteria by which the performance of the model is to be judged are often dependent upon this purpose (Welch et al. 1981).

Existing Regional Models

Currently, regional level models do not exist in all resource areas. However, some regional models are being developed. Research by Dr. Phillip Tedder, at Oregon State University (OSU), funded by the USDA Forest Service is concentrating on improving the capability to simulate timber management intensification in future national timber supply analyses. The goal is an improved timber inventory projection system that is capable of estimating timber inventories, net annual growth, mortality, removals, and timber supplies by 4 ownership classes, 12 supply regions, and 3 forest types at 10-year intervals, and with specified management regimes, commercial timberland acreages, and prices. This research involves a yield table approach in line with developing a timber age-class based timber inventory projection model for the South, Pacific North-west Westside, and Pacific Southwest, for the 1985 RPA Program Update. A yield table approach is dependent on the availability of underlying timber yield tables for the major timber species in different geographic areas.

Research conducted by Dr. Jeff Klopatek and Thomas Kitchings at Oak Ridge National Laboratory, funded by the USDA Forest Service, focused on obtaining regional estimates of wildlife abundance and distribution. Their approach used the pattern of land cover type and land use class to predict a species population level. County level land use, vegetation data, and animal population data were used to develop a discriminant function for a region which could predict the population level of a species. The vegetation data included the percentage of the land within each county in each cover type and land use class. One regional level discriminant function was developed for each wildlife species of interest. This approach is dependent upon the existence of a regionally consistent data base of variables related to wildlife species abundance and distribution. Once the discriminant function is estimated, the effect of different land use changes on wildlife can be examined as long as the assumptions underlying the analysis do not change.

Regional level models of range forage production do not exist. Forage represents only a part, that is, the available, usable, palatable part of the vegetation that is produced in the ecosystem (Mitchell 1982). Conversion factors to estimate forage from vegetation production are difficult to determine. Vegetation production (primary production) has received much attention in modeling activities. Sharpe (1975) outlined several methods that have been used to determine primary production from existing data sources, such as the RRE data and the CFI data, and existing models, such as in Rosenzweig (1968). Estimating primary production from existing data sources, such as the CFI, assumed that appropriate conversion factors exist. This is not always the case, and assumptions about these conversion factors affect the estimates of regional primary productivity (Sharpe 1975). Regional models are highly influenced by the data used to construct the models, as Sharpe (1975) noted, and Joyce (1981) showed.

CONCLUSIONS

The development of a multiresource framework in which to couch these functional analyses would facilitate the prediction of multiresource outputs. The impacts of resource management intensification would be expressed in the same or similar variables. All resources would be evaluated in response to a commonly defined set of management prescriptions. The development of the multiresource framework and the functional models would also suggest areas where better information is needed to determine resource interactions.

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ECONOMIC EVALUATION OF THE RANGE COMPONENT OF THE RESOURCES PLANNING ACT (RPA) - 1980 UPDATE

John M. Fowler

ABSTRACT: The RPA range program recommends a shift toward productive private holdings to balance fixed supply and increasing demand considerations. The reallocation methodology is theoretically sound, however, the actual resource use valuation is deficient. The suggested reallocation falls under the Theory of the Second Best and is no more defensible than the present allocation.

RECOMMENDED PROGRAM

The range program addressed by the Recommended Renewable Resources Program - 1980 update (USDA 1980) as required by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) has the following objectives: "designed to provide grazing use where it is ecologically and economically efficient to do so, and adjusted to meet social, political and environmental needs. It covers correction of serious range deterioration while maintaining short-term stability of livestock operators. Minority participation in grazing programs is encouraged." The recommended program (RP) emphasizes efficient production and improvement of rangeland condition. The planners have tackleda very large endeavor in simply assembling the data and feedback in a single manuscript. They are obviously pleased with the thoroughness of their effort and final result as expressed in the following introduction statement. "The program is shaped in part by necessary constraints or personnel ceilings and total budgets, but within these constraints it is balanced, cost-effective, environmentally sound, and responsive to current and projected needs." Not every reviewer has shared the enthusiasm purported by the authors.

The RP provides a range or high and low bounds for output levels, the high bound maintains range use at approximately the current level until 1995. After which, improved rangeland conditions would provide an additional one-half million Animal Unit Months (AUM's) increasing the total to 10.6 million after the year 2000 on National Forest Systems. The low bound would initially decline by .6 million AUM's by 1985, however after 1990, range use would converge to the 10.6 million AUMs attained by the high bound in the year 2000.

Even a cursory examination of the projected National Forest System Program outputs of the RP leaves considerable room for questions. There exists a substantial reversal for the low bound in the period 1991-2000 to jump from 9.4 million AUM's to 10.0 million AUM's while the high bound stays virtually constant from 1983 through the year 2000. This sharp transition seems to be wishful thinking and strongly indicates that the modelers should reevaluate their initial assumptions and their mathematical constructs. If this low bound jump is possible - then the high bound should be able to make at least a strong readjustment during at least one of the time periods.

The overall RPA range program indicates a shift away from federal ranges toward more productive private holdings, within the Forest Service itself the prevailing philosophy was oriented to the intensive margin. Marginal ranges with little opportunity for improvement would be phased out. Several opportunities were presented for the range sector that were deemed necessary to move toward the projected biologic potential of 566 million AUM. Biologic potential must be explained in detail; many laypersons are easily misled by this type of statement. The origin of the number 566 needs documentation or citation. The designated range sector opportunities include: improved grazing systems, range improvements, brush control, poisonous and noxious weed control, insect and disease control, taking advantage of complementary timber growth stages, and intensify research to develop cost-effective methods to revegetate disturbed rangelands.

Intensive margin expansion prevails in the above opportunities or challenges - this orientation can't be allowed to exist wholly as a wish list - but rather the shift to on-the-ground development must be accompanied by an equal budgeting effort. The emphasis on applied research and economic evaluation is a strong movement toward a productive reallocation of manpower and resources if sufficient funds exist to allow investments in long run improvements of significant quantity to capture potential economies of scale.

The goals of the range sector shouldn't be viewed in isolation; if viewed as such, it would be easy to miss some of the flavor and subtle inferences of the RP. It was interesting in some of the statements associated with the wilderness goals: "Current use levels are close to upper limits for some wilderness areas and carrying capacity will be reached in 30 percent of National Forests by 2000 regardless of investments." Interpre-

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ration, although not 100 percent certain, is that there exists an inference to further shift away from livestock production on wilderness areas. A definite need exists for research to be conducted in the area of impacts of wilderness designation on the costs, returns and organization of ranches.

PUBLISHED COMMENTS

There have been several comments published by producers, groups, user groups, and legislators. The portions of the comments that bear directly upon the range sector are summarized and included to enhance the reader's insight and appreciation of the positions taken by the various factions and the complexity of the issues at hand.

Producer Groups: The National Cattlemen's Association, Public Lands Council, and National Woolgrowers Association had major concerns about the potential for a decrease in National Forest grazing with the low bound of the RP. In addition, the possibility of interspatial shifts in livestock was very apparent. The 1980 RPA update stated that local impacts and social considerations were criteria but the producers contend that the Forest Service (FS) has only paid lip service to the criteria and didn't document how they were used.

Statements were made about the narrow scope of the "cost-efficiency" analysis that basically incorporates only direct monetary benefits to compare against direct costs. Inconsistant valuation measures were used and compared, in addition, a failure to segregate both benefits and costs attributable to non-livestock activities was apparent. The whole attitude was that livestock is competitive and not complementary or even supplementary to other uses. The narrative of the 1980 update of the RPA recognizes the favorable relationships but they aren't included in the valuation calculations. The livestock industry is beginning to fear that its future is limited on public lands.

Conservationists: The conservation position, as expounded by Peter Kirby of the Wilderness Society contends that there is a philosophical difference between public and private lands. Only public lands can provide true wilderness areas and can provide protection for numerous wild and endangered species. Public lands, therefore, should be held to a higher standard. Conservationists have a good deal in common with the livestock industry in that "grazing in some respects enhances the public lands."

Legislators: The Senate forests subcommittee chairman John Melcher (D-Mont.) emphasized that the approach of using a high bound and low bound instead of a specific target, smacks of political expediency. He wants professional foresters to make their best estimates as to what the national forests could and should produce in the next 50 years. Senator Melcher wants an additional goal added to the RP: that 85 percent of the public range be in an "improved forage producing state" by the year 2000. 18 percent of the public range is in poor condition now; the subcommittee wants that reduced to five percent. A resolution is being considered to reject the RPA 1980 update, forcing the administration to start over again.

The National Forest Products Association has also maintained that specific numbers must be set for wood consumer goals. Wilderness Society states that "The non market bounds vary tremendously, from 200 to 300 percent, for timber and range the numbers follow a narrow range. If it comes to a lean year, you know what will be expendable." The range of bounds can also lean to different interpretations by national forest regions when RPA goals are applied to their plans.

RPA GENERALIZED COMMENTS:

Bounds: The high and low bounds impart an initial impression that the resource planners have made a significant move toward recognizing the complexity of resource management. The research community has long advocated the need to move away from discrete absolute numbers toward a more stochastic orientation of at least confidence intervals and expected probability statements. Rather than a discrete number, a mean and standard deviation and other statistical moments yield additional information as to the nature and characteristics of the baseline data. Unfortunately, this wasn't the case or the reason behind the bounds. What the bounds really represent is a high-bound set of goals potentially attainable under a liberal budget and a low-bound set of goals representing the fiscal accountability of the anti-inflationary Executive Office (Krutilla 1981).

Investment Criteria

The relevant economic considerations for the 1980 RPA update aren't concentrated in the area of using appropriate tools and established evaluation criteria. The RPA analyzed investment opportunities via the Net Present Value (NPV) criteria; this is totally acceptable although alternative criteria such as the internal rate of return (IRR), the realizable rate of return (RRR), might also have been used when reinvestment opportunities and expected useful project lives are unequal and vary tremendously across alternatives (Schallau 1981). The area of concern also isn't in the selection of an applicable discount rate; the RPA analyzes outcomes with a range of 4 to 10 percent with 7 1/8 being the standard. These are reasonable approaches and totally defensible if properly applied.

Communication Channels: A basic question related to the overall orientation of the RPA is the concept of an encompassing national policy directive. Assurances have to be made that national policy is not misunderstood by personnel applying the policy in the field. Communication channels between the Washington Office, Regional Offices, Forest Supervisor's Offices and District Offices have not historically been known to be "clear flowing and pristine." Communication breakdowns can occur at every level and particularly at the position of policy application on the districts.

The benefits and costs of the RPA are being both objectively measured and subjectively estimated. Figures are then aggregated for the nation as a whole. In instances where regional and individual forest environmental management policies are the objective, then a proportionate share of the national objective isn't necessarily the ultimate "ticket" to sound management. Flexibility in application is vitally necessary, national policy should be evaluated with an additional criteria of on-the-ground application and acceptability.

Allocation

The fixed resource bases of forest and range land in the National Forests are subjected to a vast and expanding array of demand pressures. There are three basic measures which could potentially alleviate the present and expected future condition of excess demand. First, is the logical escalation of prices for all users groups and types of services provided. Second, is rapidly expending the availability and quality of resource supplies by a prudent investment combination in both the extensive and intensive margins. Lastly, increased awareness of the complementary and supplementary relationships that exist among outputs. This was addressed in the narrative of the RPA text but all output categories were unfortunately evaluated as though they were exclusively single product outputs.

Price level escalation may lead to even further distortions of equity goals due to the existence of many goods and services that are not readily exchanged in the market place. But equity apparently entered only the narrative portion of the RPA and not the actual valuation. This type of superficial "lip service" only confounds the attempt to use economic efficiency and equity as appropriate allocation devices. It is also difficult to comprehend efficient allocation when the concept of marginality either from a production viewpoint or from a utility perspective isn't incorporated or even introduced into the overall scheme of allocation.

In the context of measurement, are both market and non market goods and services being adequately addressed? Compound the measurement question with the failure to account for joint products and multiple benefits; just when you think you understand these questions, throw in the issue of the lack of conceptually valid measures of demand for environmental quality and then tack on the difficulty of empirically justifying associated welfare changes. This is the nature of the problem situation confronting the RPA planners.

Maintaining the policy of good range stewardship may not enjoy the prominent position that it has traditionally enjoyed but on the other hand it should not be treated as the residual use after the allocations to more "vogue" types of uses have occurred. The "last slice of the pie" philosophy must not be allowed to enter the decision making process either explicitly or implicitly.

Actual Use

Several of the presented alternatives of the 1980 RPA update including the low bound of the RP have proposed decreasing animals numbers in at least the short-run situation. This type of action needs additional support; the argument is at least partially valid that comparing objective market values to subjective estimates of non market values is not exactly proper. In addition to the questionable comparison there are problems with the data used in the objective calculation of net present value of livestock grazing. The Forest Service would be hard pressed to be able to come up with the actual number of livestock that are really grazing on public lands. "Actual Use" is not known on many Forest Service or BLM allotments. For any given period, the proxy that is used is the number of animals the permit is issued for minus the non-use. When this type of proxy is used and divergence exists between true numbers and recorded numbers, regression analysis will inaccurately estimate the independent variable coefficient (Freeman 1979). The same improper characterization carries through to correlation coefficients and analysis of variance and many other analysis techniques. Therefore, additional attention should be placed in the arena of rancher-FS range personnel interaction to assure more accurate reporting of true actual use numbers so range condition trend can be correlated to the number of animals actually grazing the allotment.

Adjustments

The most readily apparent 1980 RPA update recommendation for the reallocation process is changing Animal Unit month's (AUM) of grazing. Number changes are a viable adjustment mechanism but should be considered as only one of several options. Alternative courses of action include but aren't limited to changes in the season of use, the type of animal use, and the water density and distribution to expand utilization. Finally, adjust livestock numbers. Concurrent monitoring

must be established to determine long run range condition and trend. It is difficult to advocate and defend reducing livestock numbers when adequate consideration is not given to potential income impacts, changes in wealth position, reduced borrowing capacity and potentially destroying the concept of a "viable economic unit " (Gray and Fowler 1982).

SPECIFIC COMMENTS

Valuation

A key element inherent in the RPA assessment, evaluation, and allocation is the computation of "value" for which the dominant use would be ranked against other uses. As previously mentioned, when deriving a subjective measurement for a non market value, the selection of an appropriate proxy is critical. The 1980 RPA update uses the price of hay as its proxy because it is simple to calculate, the market is well established, and the hay prices are readily available. The formula for computing value of grazing per month is as follows:

Rate =	Animal Weight	x	Hay Price (per ton)	x	Factor
assumed:	1000 pound animal	x	1978 normalized price	x	.12 forage quality

The factor value of .12 reflects a value of poor short grasses or considerable weed growth. This factor was assigned as being most representative for National Forests. This appears to be uniform. After this rate was determined then $1.74 was subtracted from the rate derived from the formula to account for the services provided by the private sector.

There are several comments that need to be made about this method of analysis. The first obvious problem or least questionable area is the factor used to reflect quality. The factor really translates into simply saying that lush. green, high protein pasture is only worth .22 percent or approximately one-fifth that of baled alfalfa hay. This must be documented if such a relationship does exist. Rather than the quality differential that is purported in the RPA the (.22) rate for lush green high protein pasture might reflect the difference in value between standing forage and baled hay. But this isn't the obvious interpretation.

In addition to the problem of quality, the forage consumption rate differs drastically by animal type and age class. Further, why should just one rate be used, the quality factor should at least have the flexibility for change within forests. There is no basis for aggregating or averaging; the calculation is relatively uncomplicated. If you use state hay prices then at least use individual state quality ratings. Ideally every district should have the factor as a parameter for change in the determination of range value.

Rate Adjustment

What is the basis for the $1.74 subtracted from the calculated animal rate to account for the service provided for by the private sector. In a study conducted by Gray & Fowler (1982) the average value of landlord services was $2.14 in New Mexico in 1980 (table 1). The same unit (animal month) was used for the calculation as in the 1980 RPA update. Primary data were derived from 220 questionnaires. Landlord services such as facility maintenance, interest on improvements, checking water and cattle, moving cattle, supplemental feed, and the option of lease changes by lessee. Documentation of the calculation of the $1.74 is necessary to validate its credibility.

The consequences of livestock adjustments, severity of income change, and wealth impacts resulting from interregional shifts merit additional validity, credibility, and documentation. Potential adjustments must be supported by objectivity and knowledge; and not cursory treatment justified almost wholly on the criteria of ease and simplicity of analysis.

The most serious deficiency of the RPA is the failure to tightly document the annual values of the different dominant uses of the forest land base. Inefficient allocation will obviously occur unless all relevant public and private benefits and costs are incorporated in the analysis and resultant decisions.

Anti-dust

Large documents such as the RPA have the tendency to collect dust, this phenomena isn't due to a peculiar ionic charge but rather due to the bulkiness from the sheer volume of material and a noticeable lack of "robustness" primarily due to the type of material presented. In order to correct such a barrier to common usage at least one controversial issue should be slipped in. In the case of the RPA, many of the alternatives to the RP advocate an initial decrease in livestock numbers leading to an eventual long-run increase in carrying capacity. It is feasible to offer a written guarantee that this indeed will be the end result. The annual value has already been calculated; therefore, compound it, and compensate if not achieved. This approach has its own inherent set of problems and drawbacks but would put teeth into the achievement of specified objectives and goals of the 1980 RPA update.

Coordination

On a more serious note, massive efforts such as the RPA should not be viewed in isolation. Emphasis was placed in the increasingly important projected role of the state and private sector in bridging the gap between demand and supply of forest range related products and yet no mention was made of parallel efforts such as the Resources Conservation Act (RCA). There are obvious problems with inter-agency coordination but the free exchange of technological

Table 1. Gross and net private rangeland lease fees in New Mexico, 1980

Item	Total Amount Reported	Number Reporting Quantity	Number Reporting Unit	Average Amounts Those reporting	Average Amounts All ranchers
	dollars			dollars	dollars
Gross Lease Fee					
Per Animal Month					6.85
Per Acre					1.15
Value of Landlord Services for:					
Facility maintenance					
Per Animal Month	17,625	10,129	AMs	1.74	0.068
Per Acre	21,825	145,550	Acres	0.15	0.001
Interest on improvements[1]					
Per Animal Month	34,659	52,418	AMs	0.66	0.431
Per Acre	25,953	366,568	Acres	0.07	0.028
Checking water and cattle					
Per Animal Month	4,750	990	AMs	4.80	1.056
Per Acre	6,200	77,500	Acres	0.08	0.004
Moving cattle among pastures					
Per Animal Month	1,050	614	AMs	1.71	0.180
Per Acre	600	60,000	Acres	0.01	0.000
Supplement feed and feeding					
Per Animal Month	1,000	599	AMs	1.67	0.045
Per Acre	0	0	Acres	0.00	0.000
Lease change by lessee					
Per Animal Month	3,495	5,445	AMs	0.64	0.356
Per Acre	14,250	47,500	Acre	0.30	0.140
Total Value Landlord Services					
Per Animal Month					2.136
Per Acre					0.173
Net Lease Fee					
Per Animal Month					4.714
Per Acre					0.977

[1]Interest at 12 percent of total investment

innovations and on-the-ground expertise would do wonders to public and private acceptability of recommended programs of both RPA and RCA. Both the RPA and RCA could utilize Land Satellites for detailed assessment work; a standard data base across land management agencies doesn't seem at all inappropriate. There would seem to be a whole range of multiple-resource spinoffs that would then be institutionally as well as economically feasible.

Cost-Effectiveness

The recommended program of the 1980 RPA update has incorporated the tools of economics theory in order to justify intensified investment on rangeland. Only cost-effective improvements would be initiated; unless grazing meets this criteria livestock will be removed. This is an operationally correct procedure if the tool is executed properly. Benefits as well as costs must be accurately assessed. Are private as well as social benefits and costs included in the analysis? Is more than lip-service paid to joint products and multiple-benefits? Are costs based on efficient management? Are the following fiscal considerations included in the analysis of evaluating an improvement practice: initial capital requirements, deferment costs, opportunity cost of money, timing of expected income, costs of operation and maintenance, as well as the expected life of the practice. If the analysis isn't comprehensive and complete then the obvious economic result is Misallocation of Resources.

We in the academic community must provide the leadership, direction and accuracy from applied research results to assure that land management personnel are making decisions based on a knowledge base rather than a position of ignorance.

OVERVIEW

The RPA has taken a large step forward from the first effort in 1975. The documents are more comprehensive, encompassing and have attempted to incorporate positive public comments and feedback. The resource problems addressed are quite intangible and difficult to comprehend. Resource decisions are not clearcut and with escalating competing demands on a fixed resource base there are bound to be issues that don't lend themselves to be resolved to all parties satisfaction.

In conclusion, it is readily apparent that in order to achieve the 1980 RPA update of effective and prudent utilization there should be a gradual shift to an alternative type of livestock on federal and private rangelands. Rather than simply removing cattle from marginal rangelands in the future there should be a gradual transition toward running increased numbers of goats and sheep. This should be done for the following reasons:

A) To take advantage of the complementary relationship existing between cattle and sheep production in terms of increased forage and fiber utilization.

B) To capture and joint-product potential of multiple outputs.

C) To increase the production of natural fabrics versus the energy demanding synthetics because its going to take a lot of wool to pull over the eyes of the general public before the suggested reallocation of the RPA is accepted.

Element (c) is somewhat facetious and should not be interpreted literally. What I'm really advocating is that the RPA process has incorporated applied economics as an important criterion in reallocating scarce resources among competing needs. This is a classic forum for economics, but if incorrectly applied then the reallocation falls under the Theory of the Second Best and is no more or less defensible than the present resource allocation.

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EXTRAMARKET VALUATION FOR RESOURCE ALLOCATION:

A CRITIQUE

Ervin G. Schuster and J. Greg Jones

ABSTRACT: An assessment of the relationship between the value of benefits associated with decision alternatives and the values forgone is fundamental to an economic efficiency analysis. Substantial difficulties are introduced when the analysis must integrate market and extramarket values. This paper identifies and discusses several problem areas associated with extramarket valuation--confusion of purpose, product definition, the willingness-to-pay controversy, marginal and average values, the comparability problem, and data problems.

INTRODUCTION

It was with a modest amount of trepidation mixed with a healthy dose of skepticism that we undertook our journey into the world of extramarket valuation--"Extramarketvaluationland." Our mission, were we to accept it, was to determine what the culture was all about, inspect the writings of its scholars, and assess the extent to which what has been done corresponds to what is needed. Ours was to be a scouting trip, a kind of intellectual reconnaissance expedition. Unfamiliar territory it was. Our colleagues warned us to expect "voodoo economics" and the coin of the realm being called "funny money." Undaunted, we began and completed our mission, guided only by the beacon of economic efficiency to better illuminate "truth."

What follows is basically a report on our findings. Time and space necessitate that we share only our major impressions. Specifically, while we encountered public goods valuers, water valuers, cultural valuers, historical valuers, existence and option valuers, and more, the recreation valuers seemed to dominate the landscape and will be the focus of our report. And even with these restrictions, we will not be able to develop full-blown, analytical rationale to support our observations. If our report appears to demean or belittle the rigor and scholarship of any individual or group, that is not our intent; for, indeed, we found an abundance of both rigor and scholarship. Our remarks are organized into six topic areas: confusion of purpose, product definition, value specification, marginal and average values, value comparability, and data problems.

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THE SETTING: A CONFUSION OF PURPOSE?

Upon first setting foot in Extramarketvaluationland, one's initial impression is that the inhabitants share a common vocabulary, but the words do not always have a common, widely accepted meaning.[1] Moreover, one senses that diverse meanings are substantially linked to differences in motivation and background. While this practice can be found elsewhere, we found it to excess.

Consider the term "economic benefits." The Missoulian (a local newspaper) recently carried an article which stated that the economic benefit of big game hunting to Montana was the $386,000 brought into the State by nonresident hunters; others have argued the case of jobs created; others reject the whole notion of valuing recreation on ethical grounds. Some economists have argued for consumer surplus, willingness-to-pay, others for willingness-to-sell, Marshallian demand curves, Hicksian compensated demand curves. We have seen hypothetical fences built around the national forests with imaginary toll gates. We have seen average values, marginal values, average marginals and marginal averages. It's no wonder that they are telling economist jokes in Poland!

This illustrates a major problem which we believe permeates extramarket valuation. There is a lack of agreement as to the conceptual basis underlying "benefits," what should be done to measure them, and why, a confusion of purpose. Willingness-to-sell does not measure the same thing as willingness-to-pay; neither has much if anything to do with income generated and nothing at all to do with production costs. Yet, these and many more techniques can be found in the literature of extramarket valuation over the past two decades. Similarly, when State fish and game managers reject RPA values because they personally know of hunters who spend hundreds if not thousands of dollars to hunt big game, it seems clear that folks are not talking of the same thing. Different purposes or objectives are being served and mixed.

Lest we are to be guilty of what we accuse others of doing, let us attempt to state our perspective as to why extramarket benefits must be and what purpose this serves. Earlier, Ed Fransen discussed the legal/administrative requirement for

[1] We use the "extramarket" throughout this paper. For an excellent discussion of this term and its alternatives (e.g., nonmarket), see Sinden and Worrell (1979).

these analyses. Our rationale is less pragmatic. Rather than pursuing a lengthy discourse on micro-economic theory, let us state our position:

> The purpose of an economic efficiency analysis is to measure or describe the relationship between the value of benefits produced and the value of benefits forgone, pursuant to a particular action(s) or decision alternative(s).

Simple, is it not? We do not use words like maximization or optimization as they imply specific decision rules. We do not even refer to decisionmaking itself. No, the efficiency analysis is a pure thing. Whether and how it's used is an entirely different matter.

We should further embellish this concept. Figure 1 shows a conceptual model of a situation wherein some type of extramarket commodity could be produced at various levels via increasingly costly alternatives (A_o - A_3). An economic efficiency analysis would develop the information base for constructing figure 1.

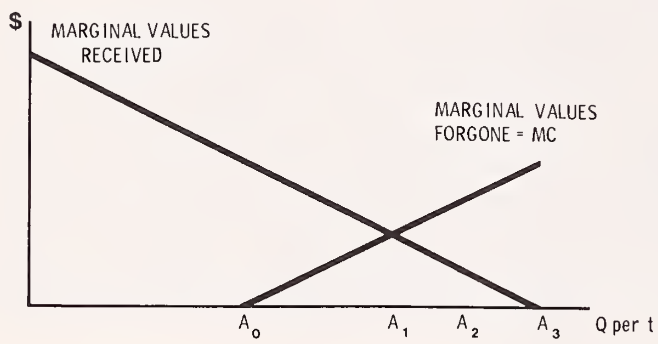

Figure 1.--Hypothetical decision alternative values.

Several points should be made. First, the relationships shown pertain to a specific time interval (t) (e.g., per season, year, or decade) which must be, but too frequently is not, made explicit. While the curves may shift over time, the process of discounting can easily make adjustments; in fact, figure 1 could be interpreted in present value terms. Second, the relationships pertain to a specific market area. Value relationships of importance are at the market level, not that of the individual consumer. Heartless as it may seem, the individual is largely irrelevant, gaining relevancy only by participation in the market. Finally, the curves reflect both decreasing marginal productivity in production and downward sloping demand, characteristic of demand forced by firms operating in imperfectly competitive markets. We have in mind a set of consequential alternatives of a program nature, not small-scale projects that have no effect on market outcomes.

The valuation of extramarket benefits is rooted in the need to assess the efficiency of resource use. This should be clearly distinguished from analyses of the effects of resource use on individuals and local or regional economies.

PRODUCT DEFINITION

The problems associated with extramarket valuation go deeper than merely a lack of shared purpose. We found inconsistency, if not rampant disagreement, as to how the quantity axis should be labeled. That is: what product is being produced? This problem is particularly important because it inhibits communication and diverts research resources into diverse, sometimes seemingly fruitless, topic areas. We will discuss two dimensions of this problem.

First, resource economists and resource managers tend to have different perspectives of the product. While the economist typically views the product from the standpoint of the consumer and the market, the manager frequently views it in terms of direct management output--critters (antelope or trout) or facilities (campgrounds or boat launches). This has caused communication problems, for the differences in product perception frequently reflect a difference in personal or professional perspective. These perspectives have been described variously but fundamentally as "ecocentric" and "homocentric" points of view. In the case of the USDA Forest Service, the homocentric view seems to prevail, at least in terms of official policy. Directives and guidelines pertaining to RPA and forest planning have defined a set of "standard outputs." The outputs of antelope management may be measured in recreation visitor days (RVDs) of big game hunting, steelhead habitat improvements in RVDs of anadromous fishing, campground establishment in RVDs of developed recreation. The upshot of this has been a marked refocus of extramarket value research; studies of a decade or more ago that may have focused on the value of a goose now focus on goose hunting.

Although agency policies may well simplify some problems of what to measure, they cannot overcome inherent ideological differences. Those believing that big game populations are inherently valuable will continue to reject the notion that worth takes on meaning only in the context of human tastes and preferences.

The second dimension to the product definition problem may be termed the "site versus experience" issue. It concerns which recreational value ought to be measured. At issue is whether the appropriate value is that of the entire recreation experience, or the value of the recreation opportunity afforded at the site itself. If it is the former, then one must value the recreation experience in its entirety--anticipation, travel, participation, and recollection (Clawson and Knetsch 1966). If the latter is the appropriate perspective, then only the value attributable to the site should be included. Both can be measured in terms of value per recreation visitor day. But the magnitude of per day value for a given type of recreation is likely to be quite different. Thus, whether or not an estimate of value appears reasonable depends upon which perspective is being used.

There would not seem to be any general conclusion as to which perspective is more appropriate. It depends on who you are, your vantage point. The governor of a State probably should look at recreation quite differently than would a district ranger. As for land management agencies, the recreation site or space is the only factor input that can be provided to the recreationist; the other input factors such as travel, gear, lodging, time, etc., are provided elsewhere, and the recreationist personally "manufactures" the experience.

Resource economists now seem to agree that the value for use of the "recreation site" is the appropriate focus for land-managing organizations providing the site only, if an economic efficiency analysis is being performed. The meaning of "site" varies with the type of recreation and the purpose of the analysis. Site may refer to a campground, a national forest, or a region, depending on the scope of analysis. (Note, later discussion will present in more detail the logic underlying why the value of the site appears to be the appropriate perspective for land managing organizations.)

The choice between site versus experience is so critically important to extramarket valuation that a task force on wildlife and fish values adopted the convention "if one envisions a fence around National Forest lands with a gate..." in order to preclude task force members from mixing approaches and confusing debate.[2] Failure to adequately define or recognize alternative perspectives is rampant in the extramarket valuation literature. The bulk of the studies we inspected seems to imply products corresponding to or equivalent to the experience level. Accordingly, it is difficult to infer site-level values from experience-level studies.

VALUE SPECIFICATION: THE WTP CONTROVERSY

Several years ago in a Journal of Forestry article, Dwyer and Bowes (1979) stated that the theory and procedures for estimating willingness-to-pay (WTP) have been developed sufficiently and should be applied to estimate benefits in appraisals of recreation alternatives. That article was accompanied by a comment (Dyer and Hof 1979) that stated that Dwyer and Bowes underestimate the complexity of applying WTP theory and that outlined some of the difficulties involved. The above articles generated a number of subsequent responses, published in the January 1980 journal. Remaining discussion was concerned with issues regarding operational estimation of WTP, such as the appropriateness of assumptions required for estimating recreation demand functions by the travel cost method.

[2]USDA Forest Service. Defining recreational values dependent on wildlife and fish to be used in regional and forest land and resource management planning. Unpublished report of the Wildlife and Fish Values Task Force, USDA Forest Service, WO; 1980.

The WTP approach has long been controversial. It seems to elicit only absolute reactions--absolute agreement, absolute disagreement, or absolute confusion. Although the debate in natural resource circles has not been nearly as eloquent, or as rigorous as the literary dialog between the likes of Hicks and Samuelson, it does exist. In the natural research arena, the debate seems to have centered around three topics: (a) can it be measured; and if so, (b) is it equivalent or comparable to other value measurements; and (c) is it a legitimate measure of value?

The theory underlying willingness-to-pay as a measure of benefits is well developed and widely discussed in connection with extramarket valuation (Mishan 1971). WTP is a dollar measure of the value people place on goods and services. It is defined as the maximum a consumer would pay for a specific amount of a commodity rather than go without. (Note: Unless marginals or averages are specifically indicated, WTP will mean total WPT, as in the literature.) Willingness-to-pay at the site includes any fees actually paid for use of the site, plus any additional amount users would pay over and above this amount. The "additional amount" should immediately be recognized as corresponding to consumer's surplus (CS). When use of a recreation site is provided to the recreationist without charge, consumer's surplus and willingness to pay are the same.[3]

WTP at the site (for a specific quantity or quantity increment during a time interval) is related to the total value of experience (again anticipation, actual participation, recollection, and travel to and from the site) in the following way:

WTP for use of a site	=	WTP for the total experience	-	Transaction costs

Transaction costs include dollars spent for goods and services associated with the recreation experience other than the site; e.g., gasoline, food, equipment, and vendor services. Money spent for these items partially reflects <u>their</u> economic demand. Including these dollars in the demand for the recreation site would constitute double-counting.

[3]The economic concept of willingness-to-pay has a rigorous, technical meaning that may be inconsistent with its intuitive, lay interpretation. While the economist envisions income constraints, marginal utility trade-offs, and more, the intuitive perception probably reflects tastes and preferences only, unconstrained by income and trade-off realities. In fact, these realities may be viewed as contrary to the idea of willingness-to-pay. Interpretation differences may result in communication problems.

Assume a production situation rather like that previously shown by the increasingly costly management alternatives in figure 1. Given the desire to perform an economic efficiency analysis, for illustrative purposes let us choose consumer's surplus as the measure of benefit--consumer's willingness-to- pay. All we need is an actual demand curve from which to measure consumer's surplus.

But not just any demand curve will do. Only a Hicks (income) compensated demand curve (HCDC) will be sufficient. In his "Revision of Demand Theory" (1956), J. R. Hicks points out the inadequacies in Marshall's approach to consumer's surplus, corrects previous statements, and more fully elaborates four approaches to consumers surplus. Hicks argued that the Marshallian demand curve (MDC) views the issue from the wrong perspective, when willingness-to-pay is at issue. While the MDC is based on a price-to-quantity approach where the consumer faces a price and chooses a quantity, Hicks advocated the quantity-to-price approach where the consumer faces an all or nothing choice for a fixed quantity and must specify the price or amount that will be paid. The area under a MDC misrepresents this amount because along it, the consumer's real income is changing, increasing for price decreases and decreasing for price increases. Both the income and substitution effects operate along a MDC. Under the MDC, nominal income is held constant; under the HCDC real income is held constant.

Hicks developed several consumer's surplus-oriented concepts widely used in extramarket valuation. Their presentation is best made through indifference curve analysis, as demonstrated particularly well by Currie, Murphy et al. (1971). Paraquoting Hicks, they define two of these concepts of special interest to us:

-- "Compensating variation" is the amount of compensation, paid or received, that will leave the consumer in his initial welfare position following the change in price if he is free to buy any quantity of the commodity at the new price."

-- "Equivalent variation" is the amount of compensation, paid or received, that will leave the consumer in his subsequent welfare position in the absence of the price change if he is free to buy any quantity of the commodity at the old price."

Randall (ca.1979) describes the Hicksian compensating and equivalent measures of consumer's surplus as differing with respect to the reference point:

> The compensating measure, by using the initial welfare level as the reference level, measures the welfare impact of changes as if the individual had a right to his initial level of welfare...The equivalent measure, by treating the subsequent welfare level as the reference level, treats the individual as if he had only a right to his subsequent level of welfare....

Hicks' compensating measure and the corresponding compensated demand curve have become known as "willingness-to-pay" while the equivalent measure is known as "willingness-to-sell."[4]

There appears to be little doubt but that if consumer's surplus is to be used, it must be computed from a HCDC. A MDC is, in general, wrong; it will, in general, overstate the magnitude of willingness-to-pay and hence consumer's surplus. Modifying figure 1, figure 2 now shows the same type of information but with the HCDC and the MDC shown. Real income along HCDC is held constant and equals the real income on the MDC when prices P_o.

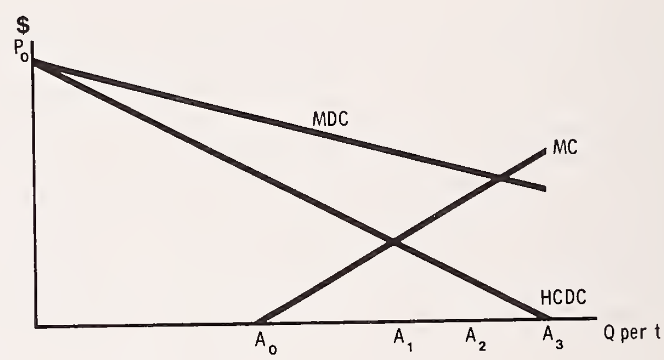

Figure 2.--Marshallian (MDC) and Hicksian (HCDC) demand curves.

[4]We confess to concern regarding the appropriateness of public agencies using the concept of willingness-to-sell. The word "right" frequently appears in conjunction with WTS. For example, Randall (ca.1979) describes the equivalent measure "as if the individual had a right to...as if he had a choice of keeping what he has or voluntarily trading for changes." Normally, producers maintain (property) rights to output until the rights are transferred to the consumer, the consumer having no prior rights in the product. Sanctioning the notion of recreationist's WTS may entail legal/policy implications.

As can be seen for any price on the vertical axis, the Marshallian measure of consumer's surplus will exceed that of the Hicksian measure. Unlike the MDC, the HCDC shows the maximum a consumer would be willing-to-pay for an additional unit of the commodity, assuming the maximum amount were already paid for each preceding unit purchased, real income constraint (Currie et al. 1971).

The reason that the forgoing is important to extramarket valuation is that, as difficult as they are to estimate, only the MDC is observable. While it may be correct, the HCDC is conceptual. So the question is: how far are they apart and what circumstances control their discrepancy? This much can be said categorically: if demand for the commodity in question is associated with zero income effect, then the HCDC and the MDC are one and the same. The demand curve is then a reflection of the substitution effect only. Furthermore, as the income effect becomes smaller, the MDC will merge into the HCDC. So it is important to be able to assess the size of the income effect in order to judge how closely the MDC approximates the HCDC.[5]

Enter Willig (1976). In his famous article, "Consumer's Surplus Without Apology," Willig identified the circumstances under which observed consumers' surplus can be used to estimate the unobservable, theoretically correct, measures. Willig's argument goes as follows: if the income effect is zero, then willingness-to-pay (compensating variation) will equal willingness-to-sell (equivalent variation) and so to estimate how closely one approximates the other is tantamount to estimating the significance of the income effect. Willig's formulae require specification of income elasticity and the consumer's income level to estimate the importance of the income effect. Apparently expecting approximation errors in the magnitude of 2.75 percent, Dwyer et al. (1977) concluded that the MDC adequately approximates HCDC. Lending additional support to this contention, Binkley (1980) writes that "Fortunately, Willig...has offered recreation analysts some relief...(showing)...that if income elasticity is small...and consumer's surplus relative to total income..., then the area under the ordinary (Marshallian) demand curve is a good approximation to the theoretically exact measures of welfare." Dwyer et al. (1977) concluded that "these conditions are almost always met for recreation output of resource management alternatives."

The implications of this line of reasoning are far reaching: willingness-to-sell estimates (approximately) willingness-to-pay (also vice versa), and either can be used to estimate (approximately) consumer's surplus. Accordingly, this justifies (it is argued) using ordinary (Marshallian) demand, such as that estimated by the travel cost method, to estimate willingness-to-pay for recreation outputs.

That a potential problem exists should probably have been detected early-on. The king-pin concept in all of this is the income effect--it must be zero (or approximately so). This is a pretty heavy-duty contention. Analytically, a zero income effect means indifference curves are vertically parallel. The equilibrium quantity of the commodity in question does not change as the price-ratio line is shifted parallel, reflecting increases and decreases in income. Interestingly, consumption is independent of income. Necessarily then, income elasticity of demand for the commodity is zero. You might then expect to find as many rich folks shooting pool as poor folks and as many poor folks shooting the rapids as the rich. Did not Clawson discuss income along with population, leisure, and transportation as factors that have underlain demand for outdoor recreation?

Empirical evidence, however, seems to conflict with the notion that the income effect is approximately zero. In Davis' (1963) study of willingness to pay for deer hunting, household income appeared as a significant variable in multiple regression models. In an article evaluating the required correspondence between willingness-to-pay (WTP) and -sell (WTS) as revealed in previous empirical studies, Gordon and Knetsch (1979) highlighted three studies in which all found WTS far exceeded WTP:

	Topic	Measure	Amount	Difference
			dollars	percent
I	Waterfowl hunting	WTP	247	
		WTS	1,044	423
II	Local fishing pier	WTP	43	
		WTS	120	279
	Postal delivery	WTP	22	
		WTS	93	423
III	BC fishing	WTP	35	
		WTS	700	2,000

[5]We should note that even a zero income effect does not alleviate concern over double-counting of values. The argument goes as follows. Consumers exhaust income either by spending or saving. While consumer's surplus may represent the value of benefits received without payment, these surpluses are in fact spent elsewhere. The "surplus" is already accounted for in the demand for other goods and services. That is, consumer's surplus values for commodity X are (at least partially) reflected in consumption and payments for commodity Y or in the level of savings. Were it not for these "free" benefits, consumption of commodity Y (and probably X) or the level of savings would be diminished. Since payments for commodity Y and for saving are already being "counted" elsewhere, to additionally count consumer's surplus values is to double-count. The HCDC tends to diminish the double-counting issue.

The large discrepancies between WTP and WTS led them to conclude a "caution" to the ready assumption that estimates of WTS can be approximated by WTP.[6] Third, in a study of goose hunting permits, Bishop and Heberlein (1979) estimated goose hunting permits hypothetical WTP at $21 while WTS was estimated at $101, a 481 percent difference. In recent research continuing the line of investigation by Gordon and Knetsch (1979), Knetsch and Sinden conducted a series of five experimental lotteries involving real money and real people. They found that in four of the five experiments, WTS was (statistically) significantly higher than WTP (in the one reported result WTP was $0.81 while WTS was $2.31, a 285 percent difference).[7] One conclusion reached was that the two measures of economic value are not equivalent.[8] We know of no empirical studies in which WTS and WTP appeared to be approximately equal.

[6]Empirical studies of WTS commonly reject extremely large answers "outlyers." This practice can scarcely be condoned on theoretical grounds. For as Hicks (1956) said:

> even in the case of a necessary commodity, the compensating surplus (WTP) is limited by income; but the equivalent surplus (WTS) may be practically infinite. (Parenthetical words added.)

Theoretically put, indifference curves need not intersect either axis.

[7]Knetsch, J. L. and J. A. Sinden. Willingness to pay and compensation demanded: experimental evidence of an unexpected disparity in measures of value. Unpub. manuscript. Simon Fraser Univ., Dept. Econ., Burnaby, B.C.; 1982. 22 p.

[8]Let us speculate on the cause of these large discrepancies beyond those suggested by Gordon and Knetsch (1979). An erroneously conceived "income" may be the culprit. While economic theory may identify "income" as important to consumer behavior, it is silent on which measure of income should be used. Should it be household or per capita, before taxes or after, including or excluding nondiscretionary payments (such as home mortgage, car payments, or college costs?). We suggest that if "income" is interpreted as "discretionary, after-tax income" the likelihood of substantial income effect increases appreciably. "Apparently" modest payments for recreation commodities do not then represent insignificant expenditures.

Where does the preceding dialog leave extramarket valuations? In shambles, we think. If extramarket benefits are to be measured by consumer's surplus as a reflection of what consumers are willing-to-pay. And, if consumer's surplus measured under a Hicksian (income) compensated demand curve is acknowledged to be correct, but immeasurable. Further, if the consumer's surplus under the measurable Marshallian demand curve can approximate the Hicksian measure, but only under certain conditions (e.g., approximately zero income effect). And if the approximation is acceptable, based on expected errors in the order of 2.75 percent. But empirical studies would suggest errors in the hundreds and thousands percent. Then, the income effect cannot be ignored, the MDC is not (approximately) coincident with the HCDC, Marshallian consumer's surplus does not approximate Hicksian, and therefore the desired measure of welfare has not, in fact, been measured. Ergo, you are in shambles.

MARGINAL VALUE VERSUS AVERAGE VALUE

Estimation of WTP can frequently be hampered by lack of a usable demand relationship, Marshallian as well as Hicksian. One way to estimate WTP when a demand function is not available is to multiply the change in quantity by the average of the before and after price (U.S. Water Resources Council 1979). This concept applied to a hypothetical outdoor recreation activity is illustrated in figure 3. P_o is the amount consumers

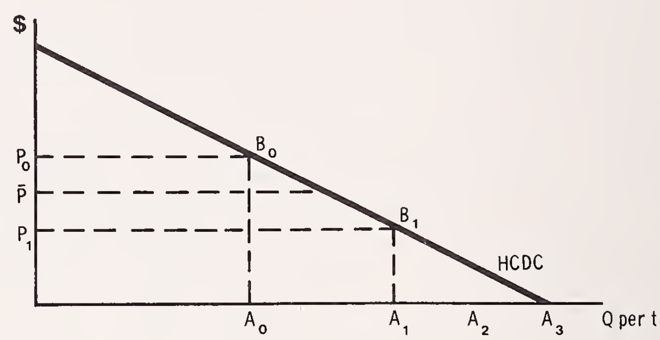

Figure 3.--WTP based on $\bar{P}$.

would pay for the last unit of output at A_o and P_1 is what they would pay for the last unit at A_1. WTP for the increment in output from A_o to A_1, area A_o B_o B_1 A_1, is estimated by multiplying $\bar{P}$ (the average) times the change in quantity ($A_1 - A_o$). This procedure is designed to estimate WTP for discrete changes in output expected from project alternatives and is a conceptually correct approximation for that purpose. In fact, the approximation is exact if the demand curve is linear.

This approach goes awry, however, when average WTP is applied as if it were price, a marginal WTP, in an economic analysis of a firm operating in a competitive market. Consider figure 4 where A_1 is the optimal level of output. Assume that $\bar{P}$

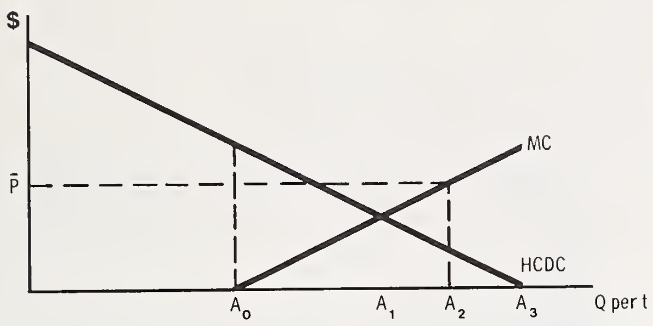

Figure 4.--Decision choice using $\bar{P}$.

represents the average WTP over some increment in quantity. The increment could start anywhere from zero to A_2. MC is the marginal cost of increasing recreation opportunities. Net benefit (profit for a private firm) equals price times quantity minus total costs. Net benefit is maximized at the quantity where price, in this case $\bar{P}$, equals MC. This occurs at a quantity of A_2.

The discrepancy between the optimal level of production identified by this approach (A_2) and the actual optimal (A_1) arises from the fact that $\bar{P}$ (or any average for that matter) corresponds to a specific level of output only. If the output level is increased, average WTP must decrease, assuming a downward-sloping demand. This relationship is ignored when average WTP is treated as if it is a price.[9]

Although this pitfall may seem apparent on the surface, it may be rather easy to fall into in practice. Applying WTP concepts to estimate benefit value is not easy. Correctly applied, it requires estimation of WTP at the margin for a number of output levels, if a marginal analysis comparing WTP for an additional unit with the cost of providing that unit is to be done. If the average WTP approach is used, average WTP must be estimated for various levels of output (as pointed out above) to have an unbiased estimate of benefits. In view of these difficulties, it may often be necessary, given time and budget constraints, to simplify an analysis by treating average WTP as a price and proceeding. The danger of this approach is that it can substantially overestimate benefits. It is in the context of average WTP in figure 4 that average values (whether based on WRC unit day values, average consumer's surplus from a travel cost model, or mean willingness-to-pay values from a questionnaire) used in analyses must be evaluated. We consider the practice of interchanging total, average, and marginal values to be a major problem in application of extramarket values. Interestingly, many opportunities to criticize extramarket values would be eliminated if marginal values were used exclusively.

[9]There is a certain degree of irrelevancy in these analyses. For even if the HCDC were correctly specified, A_1 were the alternative chosen, and if no price were charged, recreationists would still participate at a level corresponding to alternative A_3 or beyond, wherever the MDC intersects the quantity axis. Without a price charged, recreationists will always expand participation to where the marginal value (WTP) is zero.

VALUE COMPARABILITY: THE EVENHANDEDNESS ISSUE

We doubt any single issue has plagued extramarket valuation as much as has the issue of comparability. It's neither a trivial issue nor a new issue. Comparability and consistency come into focus when market and extramarket inputs, outputs, and values are merged. Dyer and Hof (1979, 1980) pointed out that if WTP procedures are used to value recreation, then in order to maintain consistency, they should be applied to all outputs included in the analysis. A decade earlier, Beardsley (1971) argued that values incorporated in resource allocation models must, among other things, be comparable to all other measures of value in the model. During the preceding decade, Wennergren (1964) said: "Unfortunately, most public recreation is not market-priced and thus estimates of comparable value are difficult. But it is this lack of conventional market pricing and not the associated esthetic values that complicates the valuation process." We are convinced that to assert "lingering doubt" and "endemic skepticism" exists would not overstate the type of reservation felt by our colleagues.

There are at least two sides to the comparability coin. The first deals with comparability among output values. This aspect has certainly received the most attention. In 1971, Beardsley said that when compared to consumer's surplus measures, "market-price values for resource uses do not include consumer's surplus values and the two cannot be legitimately compared...." Binkley (1980) and by implication Bowes and Dwyer (1980) argued that it is not necessarily inconsistent to value recreation by WTP procedures, while using market value approaches for other commodities. Both views are correct, under certain conditions.

The central issue boils down to the slope of the demand curves in question. When demand for a commodity is horizontal (i.e., firm in a perfectly competitive industry), market price times quantity is the same as WTP since consumer's surplus in this instance is nonexistent. Some may view the market in which forest and rangeland commodities are exchanged to be sufficiently large (possibly national in scope) such that resource decisions do not influence quantities sufficiently to affect price. Therefore, the demand for these commodities is flat over relevant potential changes in quantity. When this condition holds, market prices contain consumer's surplus, but it is zero.[10]

Alternatively, it can be argued that while consumer goods produced from forest commodities (e.g., lumber, paper, and meat) are often sold nationwide (or at least over wide geographic areas) at common prices, the forest commodities themselves from which these products are produced (e.g., standing timber, and forage) typically are not exchanged nationally or even over wide geographic areas. Land management organizations most commonly produce and market forest commodities, not consumer goods. It appears that markets for many forest commodities are limited to much smaller geographic areas than what some have suggested. They are perhaps more aptly described as local or regional markets. In such instances, consistency is maintained only when WTP procedures are used to place values on these commodities as well as recreation. As Dyer and Hof (1980) suggest, this presents a formidable task.

The other side to the comparability coin involves inputs. This topic has scarcely been discussed in the extramarket valuation literature. We earlier set a rather modest goal for an economic efficiency analysis--a comparison of the values produced to the values forgone. As it is critically important to measure all benefits by equivalent standards, so it is that costs be measured by the same standard as benefits. After all, they both may go into a present net worth calculation. But are they equivalent? Two aspects seem important.

The first deals with actual, out-of-pocket costs, expenditures to secure the services factor inputs. Dorfman (1972, p. 75) indicates:

> In monetary terms, the opportunity cost of producing anything is the value of the resources that it absorbs, because that value reflects the usefulness of those resources in other employments. (Emphasis added.)

Conceptually, the price paid for a resource measures its productive value in other uses--at the margin of equilibrium. Trescott (1970, pg. 284) puts it this way:

> In long-run competitive equilibrium, the price of each product tends to equal both the cost of the resources used in producing the marginal unit and also the value of other products which could have been produced with the same quantity of resources. We know that the price of each product tends to equal its marginal cost. Remember also that each input must be paid an amount equal to the value of its marginal product in the rest of the economy. Combining these ideas yields the idea that the marginal cost of one product measures the value of the product that one could have obtained with the same resources. (Emphasis added.)

Factor prices represent alternative values forgone, at the margin. It hardly seems comparable for an organization to measure some output values (benefits) on a WTP basis while inputs (costs) are assigned marginal, equilibrium values.

The second aspect of factor cost concerns time. Discounting is frequently applied in resource allocation analyses, since decisions often involve committing resources and receiving benefits over relatively long periods of time. There appears to be general agreement that the discount rate used in analyzing investments in the public sector should be based on the opportunity cost of capital in the private sector (Row et al. 1981). That is, it should measure the net value forgone in the private sector (in terms of an earning rate) to provide capital for public investments. Furthermore, as Row and others argued in recommending a 4 percent rather than a 10 percent discount rate, the rate should be a marginal rate rather than a higher, average rate.

To maintain consistency in measurement, it is also important that forgone benefits in the private sector, reflected by the opportunity cost of capital, be measured in a manner consistent with the benefits in an analysis. If they are not measured by the same yardstick, the trade-offs between public and private investments are incorrectly specified. It appears that when WTP is used to value outputs in public resource allocation analysis, a different yardstick may in fact be used. Benefits (actually receipts) underlying the private sector earning rates are based on revenue earned by producers, price-times-quantity relationships. Consistency is maintained only under one or more of the following conditions:

[10] We note the irony in this procedure. If for a given market area, a given industry could be organized alternatively as perfectly competitive and as a monopoly, with equilibria in place, then we could measure positive consumer's surplus with the monopoly and none with the competitive industry. The later situation results because each of the competitive firms has a horizontal demand curve with no consumer's surplus.

1. If all producers in the private sector, on which the opportunity cost of capital is based, are perfectly discriminating monopolists, such that all the consumer's surplus for the outputs that could have been produced would have been captured by the producers (i.e., no remaining consumer's surplus).

2. If the outputs that could have been produced in the private sector (with the dollars required by the public alternatives under consideration) would not have influenced any prices, such that consumer's surplus equals zero.

3. If the change in outputs associated with the public alternatives under consideration in an analysis would not affect WTP at the margin (WTP for each additional unit produced is constant) for any of the commodities that would be produced.

There is no guarantee that any of these conditions would be present. In fact, in view of the relatively large amount of resources associated with some land management decisions (e.g., the budgets associated with national forest plans), one would expect these conditions to rarely hold. In their absence, benefits that could be produced by public investments are overvalued, relative to benefits that could be produced in the private sector (since total WTP would be greater than market price times quantity). This tends to promote overallocation of resources to public projects, because it exaggerates present net values.

DATA PROBLEMS

Apart from the conceptual difficulties in extramarket valuation, there are some rather substantial empirical problems as well. Not intending a comprehensive review, we will highlight what we consider as major problems in three areas: output measurements, market-specific information, and contemporary techniques.

First, in order to determine total value, some measure of value must be applied to output quantity. Yet, the analytical status of mensurational techniques to estimate (predict or project?) levels of extramarket outputs could best be described as pathetic, approaching nonexistent. This is indeed unfortunate because it lends credence to those who contend that value estimates do not need to be precise because the output estimates are so unreliable. We expect that confidence intervals constructed around output "estimates" would generally include zero. But the problem is not just that of estimating RVDs per se. The problem is translating management activities into extramarket outputs (Batie and Shakman 1979). For example, a wildlife habitat improvement project must be translated into habitat characteristics. The changed habitat must be translated into changed wildlife populations, and that must be ultimately linked to RVDs of big game hunting. Right now, the most widely used technique by which this is done is called BPJ--best professional judgment.

Second, the need for extramarket value information totally overwhelms available empirical research, rather like the Sahara overwhelms the oases. If each of the 174 national forests and grasslands produced only four types of recreation--developed, dispersed, game-oriented, and fish-oriented--almost 700 demand models would be needed to quantify a point in time! Only a few dozen models have been produced over all time. Not surprisingly then, study results pertaining to a certain place for a specific point in time have been extrapolated thousands of miles, and over decades of time. One can only speculate whether the deer hunters in Montana in 1982 are like the deer hunters in Maine, two decades earlier.

Third, we feel compelled to briefly comment on valuation techniques currently in use. Since thorough discussions of these techniques are available elsewhere (Dwyer, Kelley, and Bowes 1977; Dwyer 1980; Kaiser and Marchetta ca.1981; and Johnson, King, and Hay ca.1979), we shall confine our remarks to what we feel are the most substantial concerns, apart from those already aired. Following the format of the U.S. Water Resources Council (1979) we will consider Unit Day Values (UDV), Travel Cost Method (TCM) values, and Contingent Value Method (CVM) values.

1. UDV: It is difficult to add to the thorough discrediting of Unit Day Values by other analysts, ranging from Clawson and Knetsch (1966) to Dwyer, Kelley, and Bowes (1977) to Dwyer (1980). The listing below shows the ranges of values per (general and specialized) recreation day published for various years by the U.S. Water Resources Council:

Year	General	Specialized
1962	$0.50 - 1.50	$2.00 - 6.00
1973	0.75 - 2.25	3.00 - 9.00
1979	1.07 - 3.22	4.29 - 12.87

Apparently, these values were originally conceived of as market clearing prices, adjusted in later years for inflation. Mechanical procedures have been devised to convert UDVs to values per RVD and to specific types of recreation. UDVs are commonly used as was $\bar{P}$ in figure 4, although they have no necessary analytical relationship to any curve shown. While there is no empirical or theoretical basis for these values, they undoubtedly enjoy the most widespread usage.

2. TCM: the travel cost method uses actual expenditures (measured or assumed) as a basis for specifying a demand curve for a site. It is a Marshallian-type curve, corresponding to the consumer's surplus area associated with the commodities purchased. The TCM always reflects benefits for the whole experience rather than site use alone. Since recreationists commonly pay less than WTP for nonsite inputs, some nothing, apportionment of (residual) consumer's surplus to the site is arbitrary. Methodological advances in terms of substitutes and travel time seem both promising and important. The travel time adjustment is most controversial, devolving down to questions of whether or not there <u>is</u> an opportunity cost of time for recreation and if so, how to measure it and reflect it analytically. In a recent study, Bishop and Heberlein (1979) found that the TCM estimated value changed by about 400 percent depending on choice of assumption concerning time values.

3. CVM: The contingent value method relies on a question and answer format, sometimes a questionnaire, sometimes a "bidding" game. This method suffers from SQC--severely questionable credibility. It conjures recollections of television game shows. The credibility issue has two dimensions. First, the question. It is difficult, maybe impossible, to formulate a stimulus (question) that will elicit an unambiguous response (answer) measurement on the complex variable being estimated. Any one inspecting the technical definition of Hicksian compensated and equivalent variations will surely see the point. Anyone who has written a simple straightforward examination question and is later totally amazed by the number of different interpretations given by students, will also appreciate this point. Second, the answer. People do not necessarily lie, but neither do they necessarily say what they mean or do what they say. Hancock (1973) found recreationists' behavior appreciably inconsistent with stated intentions. Apart from strategic bidding and other biases (Schulze and others 1981), people may not know of their feelings. Bishop and Heberlein (1979) found that the hypothetical willingness-to-sell value was almost twice that of actual. Driver and Harris (ca.1981) have suggested the possibility of a "lack-of-experience-in-thinking-that-way" problem. In short, it takes a real act of faith to put much credence in CVM results.

DISCUSSION

We close with a remark about the intellectual legal system we found. It is extended well beyond the normal "innocent until proven guilty" concept to which we were accustomed. There are two standards for "burden of proof." Not only must the plaintiff prove a defendant idea guilty of being "fallacious," beyond a reasonable doubt, but he must also prove that the fallaciousness makes any ultimate difference. The technical term for this is <u>quid importat</u>, roughly translated, "so what." This latter standard is very disarming to prosecutors. Based on convictions, we not surprisingly found a very low crime rate.

This then concludes the report of our travels in Extramarketvaluationland. We saw many wondrous sights. In fact, our journey was frequently interrupted by occasions to wonder. On one occasion, as we stood peering into a pool of ideas, incapable of perceiving form and substance, an old sage winked and lent us comfort by saying "not to worry, pilgrims, there's less there than meets the eye."

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RANGE ECONOMICS IN FOREST LEVEL PLANNING

Robert G. Williams

ABSTRACT: Planners on the Targhee National Forest have recently completed a land management plan for the Forest as required by the 1976 National Forest Management Act (NFMA). Regulations implementing NFMA specify several areas where economic analysis must occur. Analysts on the Targhee were able to accurately estimate the capability of the Forest to produce forage and the associated cost of production. However, the Targhee and most other Forests in the Intermountain Region do not have the capability to accurately project demand and the associated price-quantity relationships for forage.

Both the regulations implementing the 1976 National Forest Management Act (NFMA)[1] and subsequent direction in the Forest Service Manual[2] specify several areas where economics is to be considered in Land Management Planning. Some of the more obvious examples include direction to:

1. Develop a supply analysis for various goods and services.

2. Develop projections of demand including price-quantity relationships.

3. Prepare a comparative analysis of alternatives that examines, among other things, economic efficiency and distributional effects.

More recently, revisions to the NFMA regulations[3] provide additional emphasis on economic considerations in Forest land management planning. Some specific examples include:

1. Identifying the mix of resources which will maximize present net value.

2. Establishing the present net value assessment as the beginning point for formulating alternatives.

3. Identifying the alternative that comes nearest to maximizing public benefits.

At this point in time, it is therefore appropriate to examine how well the economic analysis was done in some early Forest plans - where we were weak, where we were strong, and where we could use some help from the Research arm of the Forest Service.

Since the Forest I work on, the Targhee, recently completed a Proposed Land Management Plan, I will draw on our experience looking primarily at the range resource.

First a quick orientation to the Targhee. The Forest is located in southeastern Idaho and western Wyoming. The Continental Divide between Idaho and Montana forms much of the northern boundary; the Targhee has boundaries common to both Grand Teton and Yellowstone National Parks. The Forest Supervisor's Office is located in St. Anthony, 40 miles north of Idaho Falls.

The Targhee is not noted as a "range" Forest, but does provide about 160,000 AUM's of grazing of which about 75,000 are sheep and 85,000 cattle. Approximately 200 families depend on the Targhee's range for a portion of their livestock range[4]. Range lands are in good condition and water is generally abundant. We get good vegetative response to range improvement projects such as spraying and burning due to fairly heavy amounts of precipitation.

Since the mid 1960's, the Forest has been the site of a massive pine bark beetle infestation. The resulting salvage operations in lodgepole pine stands have and will continue to provide significant amounts of transitory range in areas that have been clearcut.

We experience the usual competition between grazing and other resources. In addition to these, two unique situations are: 1) the need to coordinate grazing and reforestation to protect new timber plantations from grazing livestock and 2) the coordination necessary to grazing sheep in Situation 1 grizzly bear habitat.

The main question is, "How well did we integrate the economics of range management into Forest planning?" Since I expect the Targhee's final

[1]Department of Agriculture, Forest Service, 36 Code of Federal Regulations Part 219, September 17, 1979.

[2]U.S. Forest Service, Forest Service Manual. Chapter 1920 - Land and Resource Management Planning, Interim Directive No. 6, March 10, 1980.

[3]Department of Agriculture, Forest Service, 36 Code of Federal Regulations Part 219, September 30, 1982.

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[4]U.S.D.A. Forest Service, Targhee National Forest, A Briefing Guide for Planning on the Targhee National Forest, 1980.

plan to be released in the next month or so, and since appeals and court suits seem to be the rule rather than the exception these days, I won't answer that question directly. Rather I will explain what we did and let the audience be the judge.

It's my impression that range conservationists cut their teeth doing allotment analysis. Throwing hoops, identifying plants, clipping and weighing grass - they can do it in their sleep. We need little help in making good projections of supply. Existing allotment management plans provide an adequate data base. Although some of our allotment management plans are outdated, they are still adequate for making supply projections. Costs of supplying additional forage are well documented and readily available. An area where additional information would have been helpful is in transitory range. In the Targhee plan, we made some projections but we could have used additional data to answer questions such as: "What happens to the transitory range as trees come back?" "What are the effects on range of thinning?" "Does a short rotation age of 60 years have significant benefits for range as opposed to longer rotation ages?"

Demand analysis is a different story. We simply don't have good data when it comes to estimating demand, particularly when we introduce the requirement of determining price quantity relationships. We are able to make some rough estimates of demand by considering projections for red meat consumption, population projections and other existing and time tested methods. Although we learned a lot about the future demand for red meat, I'm not sure how applicable that is to demand for grazing on the Targhee National Forest.

My first experience working with the Forest Service was doing research at Utah State University under the supervision of Dr. Nielson on the subject of defining market areas for livestock grazing. At that time, we showed fairly conclusively that 1) different market areas do exist for grazing on National Forest lands and 2) that demand, as reflected by the price permittees were willing to pay, differs between market areas[5].

Demand is also influenced by price, availability of substitutes and other factors. Now this is pretty heavy stuff for an economist on a National Forest (assuming that the Forest has an economist), and it would seem to be an area where Research can provide some help.

Specifically, if we are going to be serious about estimating demand for grazing, we need to identify areas where the determinants of demand are similar, look at the cost (price) of both fee and nonfee uses of grazing and then develop some price quantity relationships for each area.

[5]Robert G. Williams, "Determining Market Areas for Livestock Grazing". MS Thesis, Utah State University, Logan, Utah, 1969.

This won't happen, however, if we wait for individual Forests to do the job. They simply don't have the capability; the study needs to be directed to a Regional and National level.

As it turned out on the Targhee, we ended up estimating future demand for grazing by looking at history. For example, when permits change hands, are takers readily available? What price does the permit sell for? Are there vacant allotments? What is the level of nonuse? By using this type of information, we were able to make some fairly rough estimates about the quantity of grazing that would be demanded. We did not, however, develop any price quantity relationships.

I'm happy to say that almost every Forest in the Intermountain Region can do a creditable job of economic efficiency analysis. We have several models with which to do the analysis and the job is relatively straight forward. The results, however, are only as good as the input. I believe we make good predictions as to outputs and costs. The problem, comes from the benefit side. As with demand, we don't have good data on the value of an AUM for individual Forests. The value (price) of forage will vary from area to area, and will be affected by demand and supply. If we have trouble estimating demand and the price quantity relationships, it follows that the value we use to reflect benefits will also be lacking.

The alternative is to use a value set in the RPA, a Regional value or whatever else is available. This, I believe, is unacceptable and points to an area where Research would be beneficial.

It is clear that the direction in Forest planning is to use present net value as the basis upon which to develop and compare alternatives. Obviously, the resources that will come out ahead are those that show positive contributions toward present net value. Just showing positive contributions toward present net value in itself will not be enough. The competition among resources we are seeing today assures that our economic analysis will come under close scrutiny. We will need to be able to use values that are realistic and defensible. Present net value figures are no longer accepted by everyone simply because they are generated by a computer. People are now looking at and questioning the inputs we use in our economic analysis. We need to be able to support them with solid research.

Individual National Forests can adequately take care of the supply and cost side, but if grazing is to get a fair shake, we will need some help on the demand and price side from somewhere.

We are in fairly good shape on the distributional effects assessment. Most Forests have access to and are using an input/output model. We have come a long way in this area during the past few years. Some of our coefficients may be outdated and we often find ourselves extrapolating coefficients from a State or Regional study to a local area. If Range Management was my game, I would look at the coefficients that are now being used in Forest level planning that are affected by the level of grazing.

In conclusion, we have come a long way in our Forest level economic analysis. Obviously we still have a long way to go, particularly if we are going to meet the intent of land management planning regulations. Most National Forests do not have the capability to develop the necessary data. Once we have the information, we will have the tools and ability to perform the necessary analysis. I imagine we will be looking to Research to meet some of these needs.

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ECONOMICS AND MULTIPLE USE MANAGEMENT ON FEDERAL RANGELANDS

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ABSTRACT: "Multiple use" has been one of the guiding principles used to manage federal lands for more than twenty years. Unfortunately, the application of this principle is commonly fraught with problems. Some of the most difficult problems that must be solved by economists are outlined and evaluated in this paper.

INTRODUCTION

The principle of multiple use management has a colorful history that essentially dates back to Secretary of Agriculture James Wilson's famous letter to Gifford Pinchot (see Behan 1967 for a review of much of this history). It also represents a concept that has been the subject of writers for about 50 years--references to multiple use management are plentiful and diverse. It is generally hailed by resource managers as their "guiding light" while others view it as a myth (Hall 1963, Sterling 1970). Perhaps only "conservation" is more widely used and more loosely defined. As a result, it is commonly interpreted by interest groups to meet their own needs or desires--anyone who has attended a public meeting conducted by the Forest Service (FS) or Bureau of Land Management (BLM) recognizes how commonly different interest groups interpret multiple use management in different ways. Many of the divergent opinions stem from differences in the area upon which the concept is to be applied--Ciriacy-Wantrup (1938) was the first writer I've found who recognized these differences. The first view or approach suggests that multiple use must be applied to each parcel of land and represents a "resource oriented" approach. The second or area oriented approach (Ridd 1965) suggests that a single use may "dominate" in one area while another use will "dominate" in another area and the two areas represent management from a multiple use perspective. These differences of opinion were made especially clear in the Public Land Law Review Commission (PLLRC) report (1970) and the associated hearings. Perhaps no other recommendation in the PLLRC report received as much "heat" as the recommendation that Forest Service and BLM lands be managed in accordance with "dominant use" principles. As a result, numerous writers (e.g. Pyles 1970) commented on the strengths and weaknesses of "dominant use" management. Some suggested that "dominant use" was not "multiple use", while others indicated that it was the essence of multiple use management. These discussions did not, however, lead to a consensus of opinion and it was inevitable that the disagreement concerning what constituted "multiple use" management would continue to exist.

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AGENCY ADMINISTRATION AND MULTIPLE USE

While these differences in philosophy may appear to be purely academic, they have two major implications that must be considered. First, it seems fairly clear to this writer that the BLM and Forest Service have, defacto over time, moved toward the dominant use philosophy as reflected by wilderness area designations and their concern with riparian habitat and mineral development. As a result, major shifts in use have occurred from forestry and livestock to recreation interests (Godfrey, 1978) and other special uses. While some of these shifts can probably be justified, it seems curious to this writer that they have been justified on the basis of an increasing demand for recreation at a low or zero price while the other demands, with increasing fees, have declined relative to recreation. This suggests it is unlikely that the demand for recreation on federally administered lands would have increased as rapidly had the fees charged for recreation increased as much as they have for timber, livestock grazing, or minerals (Godfrey 1982). Surely, the most rudimentary use of economics would have predicted these differences in the quantities demanded. Consequently, the general taxpayer through Forest Service and BLM policies, actions and allocations is subsidizing these user groups in a major way (Godfrey, 1982).

The differences of opinion concerning what constitutes multiple use management also have a direct impact on the economic models used. Furthermore, the theoretical construct used has a great deal to do with the research that is undertaken and what answers/solutions are sought.

ECONOMIC THEORY AND MULTIPLE USE

Essentially every economist who has written on the subject of economic theory and multiple use has used a production function approach (e.g. Brown 1976; Lloyd 1969; O'Connell and Brown 1972; Gregory 1955; Muklenberg 1964) and has outlined the criteria for the efficient use of a parcel of land by two or more competing uses. Most economists would agree that the product/product or production possibility frontier is the proper approach to use if the efficient use of a particular area is being considered. However, the following problems make this theory difficult if not impossible to apply.

Product Transformation

Most economic discussions of multiple use have either implicitly or explicitly assumed production functions of the following type:

$$y_1 = f_1(x_1, x_2, \ldots, x_n, y_2)$$

$y_2 = f_2(x_1, x_2, \ldots, x_n, y_1)$

where

y_1 = one product such as cattle

y_2 = second product such as deer

x_i = fixed bundle of inputs such as water, grass, browse, cover, etc. needed by the two products.

From this model a product transformation curve is derived such as the one shown below.

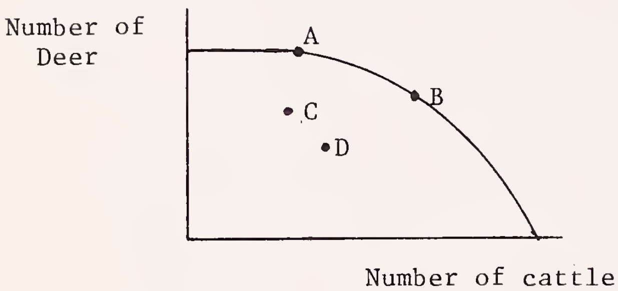

Figure 1.--Hypothetical transformation curve between deer and cattle.

A movement from point A toward point B is said to be efficient if the relative value of cattle is greater than the relative value of deer at point A. But what is assumed if we are on the transformation curve and what is assumed as movements are made along the transformation curve? First, it can be shown that it is necessary to have all inputs allocated efficiently (MRS = Px_1/Px_2) before one can be on the product transformation curve. However, it is doubtful that these conditions hold for most publically (or privately) administered lands. This suggests that most resource allocation decisions are made someplace interior to the product transformation frontier such as a movement from point D to C in figure 1. This also suggests that more effort could (should) be allocated to research that would improve the efficiency of public institutions (McKean 1972) and thus move society toward the production frontier--this is what is implicitly implied by many range managers when they contend that "properly managed" rangelands could produce more livestock and wildlife with no additional resources. As a result, research efforts that are designed to find the most efficient point on the production possibility frontier (MRPT = $Py_1 \div Py_2$) will not be successful if one can not be sure if the movements are in fact movements along a production possibility frontier.

While the above contains many fruitful areas for research, most efforts to estimate a product transformation curve for range products will fail because the above theoretical scenario is incorrect or at least incomplete. For example, a movement from A to B assumes that the fixed bundle of inputs (x_i) remain constant. However, essentially all of the range research I've reviewed refutes this assumption--i.e., the bundle of inputs does not remain constant when more or less of one or more species graze an area. This suggests that the following functional relationships apply.

$y_1 = f_1(x_j)$

$y_2 = f_2(x_i)$

$x_i = f_3(y_1, y_2)$

$x_j = f_4(y_2, y_1)$

where for example,

y_1 = one product such as cattle

y_2 = a second product such as deer

x_i = bundle of inputs consumed or used by cattle

x_j = bundle of inputs consumed or used by deer

and where

$x_i \neq x_j$ which implies that the two outputs (y_1 and y_2) need not use the same bundle of inputs (e.g., sagebrush). This theoretical scenario suggests that effort be expended to estimate the technical externalities (Buchanan and Stubblebine 1962; Bator 1958) associated with using range lands--i.e.

$$\frac{\partial y_1}{\partial x_j} \gtreqless 0 \quad \text{and} \quad \frac{\partial x_j}{\partial y_2} \gtreqless 0 \quad \text{or} \quad \frac{\partial y_2}{\partial x_i} \lesseqgtr 0 \quad \text{and} \quad \frac{\partial x_i}{\partial y_1} \lesseqgtr 0$$

which is not the same as $\frac{\partial y_1}{\partial y_2}$ when x_i and x_j are assumed to be constant under the traditional approach that has been advocated by economists. This does not mean that the traditional approach cannot be used but that care should be used to ensure that the correct theoretical construct is applied. For example, when timber is removed, more forage is generally made available for grazing animals because grass, forb and browse production is enhanced. This suggests that livestock grazing and timber production are competitive. However, the grazing of areas that have been seeded to trees will generally enhance tree growth because competition for space, nutrients and sunlight is reduced which suggests a complementary relationship. However, it must be remembered that these differences exist because the undergrowth (grass, forbs and browse) did not remain constant. This suggests that there is generally not a direct functional relationship between timber growth/production and livestock grazing. However, there is a direct functional relationship between timber growth, forage production, and livestock grazing. Thus, care must be exercised in carefully defining what variables are being measured.

One should note that the traditional biological definition of competition used by range scientists is analogous to the externality approach suggested above because competition is defined to occur when the same input is desired by two or more species (e.g., Salter and Hudson 1980; Stoddart and others 1975, chapter 11; Heady 1975, chapter 9) such that some input (water, forage, space) is limiting--i.e.,

$$\frac{\partial y_2}{\partial y_1} < 0 \quad \text{because} \quad \frac{\partial y_2}{\partial x_i} > 0 \quad \text{and} \quad \frac{\partial x_i}{\partial y_1} < 0.$$

This is also the same conceptual approach used in operations research (e.g., LP and goal programming models) and simulation models--input constraints become binding when forage or habitat requirements are given or defined. This suggests that the traditional product transformation curve suggested by most economists in the past is generally not applicable to multiple use decisions on rangelands, except as a conceptual construct, because a traditional production possibility frontier, with a fixed bundle of inputs, cannot be estimated for livestock grazing and most other uses of rangelands.

Prices

If a production possibility frontier could be estimated, the efficient use of resources will occur when the rate of product transformation is made equal to the ratio of the prices of these products (any economic principles text reviews this theory). Unfortunately, comparable prices for many of the products produced on federal rangelands do not exist. For example, it may be possible to estimate the value of livestock and range forage for domestic livestock but the methods used, to date, to value recreation or hunting do not allow one to derive the value of the deer or the forage they consume. Some misguided efforts have been made to derive these values but a fallacious assumption is needed as the following example illustrates. Suppose a demand curve has been estimated using one of the methods available (see the publication by Dwyer and others 1977; for a review and evaluation of these methods) and an average consumers surplus of $50 per recreation day is estimated. It is then determined that an average hunter spends five recreation days to "bag" his deer. It is then assumed that the deer is worth $250 ($50/day x 5 days). However, this implicitly assumes that the only value that the hunter receives is from "bagging" the animal. However, the $250 represents the consumer's surplus of the total experience not just the deer that is bagged. This problem is analogous to having a $20 steak dinner in a nice restaurant and claiming that the value of the steak alone is $20 and that the other items consumed (atmosphere, waiter services, other food, etc.) are worth nothing. Therefore, it is necessary to separate out the value of the other associated services before the value of the deer can be determined. Furthermore, numerous writers have questioned the validity of the methods used to value recreation (Schuster 1982).

However, even if many of the theoretical objections raised by these authors were overcome, there remain a number of problems that must be solved before they can be used in allocating competing uses. First, the bidding game and travel cost methods yield average consumers surplus values. It is therefore necessary to obtain comparable values for all resources being allocated (e.g., both consumers surplus as outlined by Martin and others 1978). Furthermore, both value estimates must represent marginal values rather than average values if marginal changes in use are being contemplated. For example, the values for most recreational use of federal lands may be large on the average but if consumers are rational and if no fees are charged for using federal lands, the value of an additional or marginal unit may be very small or zero. Thus, allocations that favor recreation may not be justified at the margin. Additional problems are raised where option and existence values (Bishop 1982; Miller, 1981) are considered. While option and existence values probably exist for endangered plants and animals it is doubtful that they apply for species that are plentiful. Furthermore, it is doubtful that these values are large at the margin when increasing rather than decreasing numbers are being advocated. However, even if all of the above problems were overcome, no defensible method has been discovered for making the transition from consumers surplus values per visitor day to the value of a deer or other form of wildlife. Some have suggested however, that the product transformation curve should involve livestock and hunting (rather than livestock and deer) but this raises its own set of problems (e.g., do hunting values change when the number of deer that exist in an area increase or decrease) that are beyond the scope of this paper.

The above discussion has emphasized the need for empirical work concerning the biological relationships associated with using rangelands as well as the need to have comparable prices or values. Unfortunately, these are not the only problems that exist because many range managers (and economists) confuse allocation problems associated with technical (biological) externalities (e.g., impact of livestock on riparian habitat) and those associated with user preferences or utility user satisfaction (such as how recreationists perceive the presence of wildlife, wild horses, or a strip mine).

USER SATISFACTION

Popular literature (e.g., Outdoor Life, Sierra Club Bulletin) is replete with examples that contend that recreation and livestock grazing are competitive. However, I have not been able to find any empirical evidence that both livestock and recreation directly compete for the use of any input (space used for camp sites and water holes is probably the only exception). Therefore, from a biological point of view these two uses would not be competitive (∂ recreation/∂ livestock grazing = 0)--i.e., the amount of recreation does not change when livestock grazing in an area increased--because the removal of forage by livestock (∂ forage/∂ livestock grazing) has no effect on recreation (∂ recreation/∂ forage = 0). They may be competitive if forage is an intermediate product, however. For example, the consumption of forage by livestock (∂ forage/∂ livestock grazing) may affect the amount of forage for deer (∂ deer/∂ forage) which could affect hunting and recreation (∂ recreation/∂ deer). However, it is doubtful that most recreation interests and livestock grazing are directly competitive from a biological point of view. This does not mean however, that these uses are not competitive or complementary as perceived by man. For example, a person may perceive biological diversity, deer, livestock, or other humans as being either a positive or negative influence on a recreational experience. This then represents a fruitful area of research

which lies at the heart of most of the literature concerning recreational carrying capacity (e.g., Godfrey and Peckfelder, 1972; Wagar, 1974; Stankey and Lime, 1973). It also represents an area of research where social scientists can contribute to the resolution of apparent conflicts between user groups as perceived by rangeland administrators but which have little, if any, empirical basis.

ECONOMICS AND AREA ORIENTED MULTIPLE USE MANAGEMENT

The preceeding discussion has emphasized the need for research concerning resources and their interrelationships. Those writers who have advocated a dominant or single use philosophy have generally failed to recognize that these interrelationships must be determined before a dominant use for an area can be determined or justified using traditional economic theory or models. Similarly, however, studies designed to resolve possible multiple use conflicts must make greater effort to recognize the potential for allocating resources in a suboptimal manner if a regional or national perspective is not used. It is recognized that this perspective often leads to a central decision making framework but these broader issues must be considered. For example, many of the ranchers in Wayne County, Utah, will be affected by three BLM grazing EIS's (Mountain Valley, Parker Mountain, and Henry Mountain) and two similar Forest Service evaluations as well as proposed elimination of grazing of Capital Reef National Monument. Each of these planning efforts and associated decision documents involve reductions in the use of federally administered lands. It is not likely that any one of these decisions will have a "significant impact" on these operators but their aggregate impact is probably large. Similarly, administrators must recognize how recreational developments or allocations in one area can affect patterns of use in other areas (Knetsch 1977; Cuddington and others 1981)--i.e., what is the role of substitutes in resource valuation and multiple use allocations.

CONCLUSIONS

Perhaps the PLLRC report best summarized the usefulness of the concept of multiple use when they stated the following.

> . . . the meaning of the term "multiple use" as a general expression of land use policy should be distinguished from the manner in which land use and management actually occur in a particular area. We recognize that nearly all public lands are capable of producing a variety of values, but we do not believe that this means that these lands are necessarily managed for multiple purposes. It is also our belief that multiple use has little practical meaning as a planning concept or principle.

This does not mean however, that economic principles or multiple use concepts cannot be used in helping make these decisions. It does suggest however, that they must be used wth care. Furthermore, the above discussion suggests the following.

1. Federal land administrators need to become informed concerning when and how economic information can be used in helping resolve user/use conflicts.
2. There is often a large gap between the theoretical solution and the correct use of economic methodology. As a result, it is easy for some to misapply the tools available.
3. The factors and relationships that are critical to a decision must be carefully identified before the methodologies outlined previously can be applied. For example, what factors (biological and/or social) make particular uses competitive?
4. Much of the information that is needed for an economic analysis is either not known or misdirected. This suggests that research is needed in the following general areas:
   a. The valuation of wildlife/recreation activities such that the results can be compared to values for traditional commercial uses including the role of substitutes.
   b. Estimation of the interactions between the use of various resources by wild or domestic animals as well as man and how or when food, habitat, and space requirements overlap.
   c. The impact of other uses on recreational activity and satisfaction.

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EXTERNALITIES CAUSED BY MULTIPLE USE ON PUBLIC RANGELANDS

Fred J. Wagstaff

ABSTRACT: Multiple use on public lands often creates spillover impacts (externalities) on adjoining landowners. Wildlife are a good example since they use lands without regard to ownership. Such use competes for forage with domestic animals and can adversely affect rancher income. Ranchers are seeking recognition of this contribution toward providing wildlife habitat and forage.

INTRODUCTION

This paper stems from discussions with members of the National Cattlemen's Association and Forest Service personnel over the past several months. The livestock industry is expressing concern that private land contributions in providing habitat and forage for wildlife are not adequately recognized by the public or land managing agencies.

Further problems arise in that ranchers often perceive wildlife-oriented multiple use decisions on public rangelands as reducing available public land grazing, and in some cases, also imposing additional competition upon their private rangelands. This type of problem could be particularly significant in the West because of the physical and economic relationships between public and private lands.

Because many western ranches are tied closely to use of public rangelands, the actions of managers of these public lands directly affect the profitability of livestock raising. Decisions to increase wildlife on public lands will affect all lands used by animals during their life cycle regardless of ownership. Many game animals have dietary overlaps with domestic livestock and compete to some degree (Smith and others 1957). The competition may become very severe when critical wildlife habitat is involved (Riordan 1957). Often winter and spring game ranges are more limited than summer and fall ranges. A high degree of competition can result when livestock grazing exists at high levels (Skovlin and others 1968; Julander 1955). As a matter of policy, public agency managers are required to allocate a portion of range forage to wildlife use (Forest Service Manual 1978).

The purpose of this paper is to provide a brief review of the concept of externalities, some examples showing how externalities arising from public rangeland use policies are causing problems, and a suggested course of research to address these problems. The paper was prepared to stimulate thinking and discussion about a perceived problem rather than reporting specific research results.

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GENERAL ECONOMIC THEORY

It is generally accepted that actions taken by individuals or firms often have consequences that affect others and are beyond control of those affected. When these impacts on others are positive we say an external economy exists. When negative consequences occur to others it is called an external diseconomy. In some literature these effects are called spillovers (Watson and Holman 1977).

The concept of externalities has traditionally been explained by reference to pollution problems where actions of one party cause a reduction in quality of a resource, such as air or water, for another party. The explanation of why one party may deliberately choose to cause some reduction of quality of another's environment is somewhat complex.

The "law of commons" or concept of public resources provides a partial explanation. In essence this concept suggests that anyone looking after his best interest will not be fully concerned with the impact of his actions upon the common resource. At worst, he will only be affected by part of a reduction in quality. He is better off absorbing some negative impacts than if he were to bear the cost of treating the pollutant (internalize the cost). In other words, private benefits and costs may well differ from social benefits and costs. A common example is the overuse of public rangelands prior to establishing regulations and setting up administrative agencies to manage them. Any single livestock operator had no incentive to reduce use because someone else would use what he did not.

This contention is supported by the traditional viewpoint of "the economic man" who is driven by profit maximization (and efficiency in production). To maximize profits a firm wants to produce at the lowest possible cost per unit consistent with maximum net return. Although Martin (1966), among others, has documented the fact that ranchers often have goals other than maximum net profit, efficiency in the production of saleable livestock remains a major goal for livestock producers. Anything that causes increases in costs is of concern because this is the part of production that is under the most control by the rancher. Individual ranchers have little control over selling prices of livestock due to a highly competitive market structure.

Following the concept of efficiency a bit further, we see that ranchers will attempt to use the least costly feed for livestock production. Anything that reduces the amount of a relatively cheap feed source will increase production costs. The source could be public land forage, or even private range forage if fees, competition with other uses, weather, or other factors increased its cost. If the only change in the production process is to replace the cheap feed with more expensive, but not necessarily better, feed then net profits will be reduced.

A rancher may respond to less public range forage by leasing private rangeland.

A Pollution Example

Because pollution problems are classic examples of externalities it would seem beneficial to review an example. Let's think of a water course as the recipient of effluent from some production facility. If viewed from the polluting firm's standpoint, production costs are being minimized because the cost of dumping effluent into the stream is less than treating the effluent. The downstream user views pollution as an added cost if the water must be treated prior to use. Production costs are increased over the prepollution state due to the costs of treatment.

Whether this situation is good or bad from society's point of view depends on whether treating the water downstream is the most efficient way of handling the pollution. As pointed out by Kneese (1964), if the cost of treating the effluent at the source is less than treating the water down stream there would be a net social gain from requiring treatment at the source.

Several writers have suggested various schemes of payment or compensation ranging from discharge taxes to subsidies for treatment facilities (Krutilla and Fisher 1975). Basically the argument of those suggesting such schemes is that society would be better off by paying the party who could most cheaply clean up the pollution. Krutilla and Fisher define costs and benefits as:

PC = Private cost of treatment
PB = Private benefits from treatment or discharge without treatment
SB = Benefits to society from treatment
SC = Costs to society for treatment

They then argue that if $PC < SB$ and $SC > SB$, then society could afford to pay up to the point that $SC = SB$ although $PB > PC$ will also result because all charges in PC may be covered by the payment.

Such an action may well be questionable from an equity point of view because of the transfer payment to the party treating the pollution. It might be that $PC \geq PB$ for a party bearing the tax.

Another method of causing a cessation of pollution has been the class action lawsuit. In an action of this type, courts will allow persons with minor interests to band together to seek legal remedy for damages. If successful in this action, the group would require the polluter to internalize the cost of treatment facilities. Such an action would affect the profit structure of the firm and its competitive position by making production more costly while none of the beneficiaries would directly reap substantial benefits.

Rangeland Examples

There are many examples of externalities involving rangeland use, but only two will be given to illustrate the point. An external economy exists for many areas in the functioning of rangelands as watersheds. The beneficiary of added runoff from range management may be many miles downstream and bear no portion of any costs associated with the production of additional water. In most western States, water rights have been perfected and are recognized as property rights which can not be abridged without payment. This means that the owner of the watershed cannot charge the user of the water, use it himself, or reduce the quantity or quality. Recent court decisions have ruled that even the Federal government cannot use more water than needed for livestock purposes on rangelands without perfecting a water right under State law. The implicatons of such a ruling are great because almost all uses of lands in the West depend on the use of water.

Wildlife present an interesting situation because they are considered to be property of the State and as such a common resource to a degree. Some species of western wildlife range over a fairly large area during a year to meet nutritional requirements (Skovlin and others 1968). During the course of a year it is not uncommon for some animals to use State, Federal, and private rangelands as they migrate, usually as a function of snow depth and vegetative growth stage (Kufeld and others 1973; Robinette and others 1977).

Hunting wildlife, even on private lands, requires purchase of a State license or permit. Game numbers are managed in a gross sense by the State Fish and Game Department through setting seasons, bag limits, and numbers of permits. Little evidence indicates that license fees are a limiting factor for resident hunters. Considerable evidence suggests that license fees do not represent a large portion of the value attached to game animals (Wennergren and others 1973). Considerable consumer surplus is believed to exist for wildlife users, although techniques for estimating it for a given situation have not been completely successful.

Many ranchers in the West do not charge for hunting on private lands either because the game is not on their lands during hunting season or for various personal reasons. However, it is clear to even the casual observer that private lands provide significant wildlife habitat in many areas. Almost all pheasant habitat is on private lands; other species such as antelope are found mainly on Federal lands.

With the exception of damage payments, the States generally do not make payments to landowners who contribute to the forage requirements of game animals. The State of Wyoming did return a portion of the antelope permit value to the rancher for a time in an attempt to open more lands to hunting. Unless the resources used by the wildlife on private lands have no alternative use (zero opportunity costs) there is some loss to the private owner. The degree of loss depends on the value of alternative uses such as livestock production or other activities.

It is well known that dietary overlaps exist between livestock and big game (Kufeld and others 1973; Riordan 1957). The degree of competition varies with season, location, climatic variables, and other circumstances to the point of preventing generalizations.

Range revegetation projects have been completed on hundreds of thousands of acres of public and private lands in the West. One purpose of government-sponsored projects is to improve wildlife habitat with the end purpose being greater recreational opportunities. If this improvement causes an increase in wildlife populations, the intermingled lands required to meet habitat requirements will receive additional use. This increased use of forage by wildlife may increase competition with livestock and adversely impact ranch costs and incomes. This is a case where a public agency decision causes external diseconomics to occur--symbolically SB $\geq$ SC, but PB $\leq$ PC--social benefits may equal or exceed social costs, but private benefits maybe are less than private costs. This suggests that society or that part of it receiving the wildlife benefits is being subsidized by the rancher or other private landowner. This is a case of induced external diseconomy as viewed by the livestock producers.

DISCUSSION

Is it fair? Should private individuals be forced to subsidize another group? Of course, we must realize this is a two-edged sword. If we were to decide that all contributors to wildlife production should receive full value for their contribution, some landowners who now charge for hunting may have to share their revenues. In the general sense, societal welfare would not be reduced by redistribution of benefits and costs among individuals. If SB $\geq$ SC society would want to increase wildlife populations.

Of course, the rancher who must share limited forage with wildlife and yet cannot directly share in the benefits has little economic incentive to produce more wildlife or in fact even maintain current numbers. His costs are increased with no corresponding increase in benefits. Ranchers do have an economic incentive to change the system so they can share in the benefits, but may not have the political power to make the needed legislative changes. Consumers (hunters and other recreationists) currently enjoying the consumer surplus, would be expected to resist any change that would reduce this surplus through increasing the price of hunting or nonconsumptive recreational uses of wildlife.

RESEARCH NEEDS AND OPPORTUNITIES

Much information about the general nature of externalities of rangeland use exists and the theoretical base for further study appears adequate (Watson and Holman 1977). However, information concerning the magnitude of the problem in real or relative terms is largely lacking. Considerable study is needed before informed judgments can be made about the distributional issues arising from externalities of wildlife rangeland policies.

For example, I know of no method that estimates, on a recurring basis, the amount of forage harvested by game animals from lands of various ownership. In fact, we have real problems in estimating numbers of game animals. It would be also be necessary to acquire information on dietary overlap of various species for different seasons and to translate this into transformation or tradeoff functions for a specific case study. Were this done, the physical parameters of the problem would become comprehensible, if not manageable. Although much work on diets and overlaps has been published, much remains unknown. Several investigators have reported research indicating little conflict on "properly stocked" ranges (Smith 1961; Skovlin and others 1968; Kufeld and others 1973; Smith and Julander 1953; Riordan 1957; Johnson 1962; Robinette and others 1977). These authors, however, indicate there can be severe competition on overstocked ranges with concurrent use.

Once the physical data have been assembled, analyzed, and evaluated, an economic analysis can be applied. Or can it? To solve the problem, the relative value of products resulting from alternative uses of the forage is necessary. This means, that as a minimum we must be able to determine the value of recreation use and livestock use of the forage. Because much of this information is extra-market in nature, the going will be tough and slow and subject to much disagreement.

The problem, or at least certain aspects of it, seems amenable to research. A start would be to determine the magnitude of the problem. Perhaps the National Cattlemen's Association could help by providing estimates of big game animals spending time on private lands. State Fish and Game Departments could also help.

A second avenue for research would be to determine for specific situations (a case study approach), the actual competition for forage and the resulting economic impact. This study could look at levels of use and season of use. This would address the concept people hold about the deer-livestock transformation function. Intuitively, the hypothesis to be tested is that a combination of uses will yield the greatest net social benefits. A companion hypothesis is that a combination of uses would also maximize net private or rancher benefits. Although not fully transportable, the information gained would help define the problem.

Research could also yield results by looking at the valuation of rangeland goods and services, particularly those of an extra-market type. This information is needed if sound judgments are to be made about management of rangelands, both public and private.

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FIRM LEVEL ECONOMIC ANALYSIS

Darwin B. Nielsen

ABSTRACT: A basic understanding of the ranch firm as the decision-making unit within the range livestock industry is essential for one working in the area of range economics. Problems of aggregation from the ranch firm to the livestock industry still pose serious limitations for many research problems. Ranch budgeting is an important tool that should not be ignored when training students in several speciality fields related to range economics.

This topic seems so fundamental to any discussion of economics that I have a difficult time in deciding what to say to a group of professional agricultural economists dealing with range economics problems. Yet we probably need reminding of some of the basic premises upon which we base much of our research and policy recommendations. The scope of a symposium on range economics obviously includes both macro- and microeconomic considerations. A review of the program indicates that both areas of economics are being discussed.

My task is to say something about firm level economic analysis within the overall context of range economics. Obviously, the ranch unit is the business firm level economic entity to be discussed. A ranch is a particular business firm which combines resources in the production of agricultural products. This business may be a single enterprise unit or it may combine several enterprises to form the business. Since the ranch is the decision-making unit in the production of agricultural commodities, it is both a buyer and seller. The rancher purchases inputs and transforms them into products which are sold. It should be noted that the amount of products, which will be produced in the aggregate, is determined by conditions confronted by individual ranch producers. All adjustment decisions in resource use must ultimately be made at the ranch unit level. This is important to remember when dealing with public land policy decisions. Although changes in resource availability may be made by the management agency, the ultimate adjustments must be made by the ranch decision maker.

What information can one expect to gain by a study of the ranch firm? First, a study of the firm could provide one with an understanding of the ranch business as it now exists, which would include sources and levels of income, costs of doing business (fixed and variable), the capital investment required, and the combination of resources required to make the ranch a functional business unit. Second, courses of action may be found that would lead the producer to make more profitable use of his resources. The third reason for studying the ranch firm is to be able to predict the consequences of changes in economic conditions on the production of the ranch and, in turn, on the aggregate amount of products which will be available for consumption. A related reason for studying the ranch firm is to estimate the economic impact of proposed changes in public land use. The environmental impact studies of the BLM have initiated a great deal of interest in studies of the ranch business.

From a societal point of view we are interested in seeing if ranches have the capability of producing more product from a given level of inputs; if this can be accomplished society gains in that a greater quantity of goods is available for distribution among the people.

Early in the development of range economics as a study area, it was recognized that aggregation to a population from a sample was a problem. It seems that within the general area of range economics we have several problems of defining which firms are part of the system we are concerned about. Do we limit ourselves to a study of ranches that get a "substantial" amount of their forage from rangelands? If we do this, we are left with a decision as to how much is "substantial." We also have another problem in that we have only considered a small portion of the firms that produce sheep and/or cattle. When one analyzes the expected impact of changes within the range livestock industry on the total livestock industry, he needs to know about the economic structure of the entire industry. On the other hand, when a change from outside is expected to impact the range livestock industry, we need to know the structure of this segment of the industry.

The livestock industry is characterized by a wide variation in the size of the units that produce cattle and sheep. The size of these units vary from a few head of livestock on a farm to ranches with several thousand head of livestock. If one analyzes the size distribution of producers, he would find the majority of the producers fall in the small size end of the spectrum; and the majority of the livestock are produced by a few large operations.

Public land agencies are faced with the same problem of wide variation in size of grazing permits. In some cases the land managers would like to ignore the problems of the small permittees, less than 25 head; however, they often carry considerable political influence that cannot be ignored.

Size is not the only variable that should be considered when aggregation from firm level data to some other defined population. Baker (1964) discussed spatial classification of ranch firms to increase homogeneity. He also suggested other factors

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that should not be ignored. "For example, many firms may have much in common by reason of similarities of age, education, or financial condition of the operator; degrees of specialization or mechanization of enterprises; and similarities in the availability of off-ranch employment of labor and other resources used in the production process."

USDA has used a combination of spatial characteristics and type of operation to increase the homogeneity of ranch populations from which representative budgets of ranch firms are constructed. For example, some of the budget titles are: cow/calf/yearling enterprise, 50 cow herd mountain area; cow/calf beef cow herd, 1,000 and over head of cows, High Plains subregion; sheep enterprise: over 2,500 head of stock sheep, Mountain subregion, range lambing/public range and sheep enterprise: over 1,000 head of stock sheep, Great Basin subregion, shed lamb/public range.

The difficulties with an extremely heterogeneous livestock ranching industry were discussed by Wheeler in 1962. He found that for a sample of about 500 ranch observations covering a fairly large area, and with parts of the total sample covering smaller subregions within which the ranching operations were thought to be fairly homogeneous, there was a failure of input/output coefficients to cluster in a manner that would justify designation of a representative ranch. Based upon his samples and statistical tests, he concluded that any given ranch operation would be as representative, or as nonrepresentative, as the overall average.

Kearl (1965) concluded the following in a discussion of a paper by Caton on the problems of aggregation. "In view of the extreme heterogeneity of the range livestock industry, the diversity of production conditions, the difficulty of obtaining data which can be said to be truly representative, and the very tentative and unproven state of the arts of making aggregate estimates of production adjustments, it may be worthwhile to allow other people to experiment with the state of the arts for making these estimates. People in range (economics) research might find their time used profitably if they concentrate for a few years merely on attempting to find out what the range livestock industry really is and what some of the important coefficients are.

I am not sure how much progress we have made over the last twenty years in solving the problems of aggregation in the range livestock industry. If we have made significant progress, I am not aware of it. We use the concepts of representative or typical ranches for many of our analyses, but I have never seen a discussion on the methods of moving from the typical ranch to the ranch population if one was trying to estimate the supply response of some change in ranch input.

Budgeting is an important technique that should be given more emphasis in our student training programs. I looked through some of the new textbooks on farm management. None of them treated budgeting in enough detail that one could go out and construct a farm or ranch budget if all the training he received was that covered in these textbooks. In my opinion an agricultural economist needs to have the experience of going through all the minute details of developing farm and ranch budgets from raw data gathered from ranchers. One of the major accomplishments of the regional research project W-79 was that the assumptions used in constructing ranch budgets were standardized so that comparisons of ranch budgets in different states could be compared. The USDA budgets compiled from the budget generator are good and make the data available to many more of us to use. However, the availability of these budgets does not lessen the need to know how to develop a budget from raw data or to know how to get budget data from ranchers.

We need to know more about how ranchers react to changes in input or resource availability. An analysis of the ranch firm could provide one with insights as to how ranchers adjust to such changes. One might be able to determine which resource substitutions are made and why that particular pattern of adjustments was followed. The problems of adjusting to changes in resource availability are compounded when many ranchers in a local area are faced with the same problems. They are all trying to find substitutes for the same resource and could very well exhaust the supply of substitutes and/or cause their prices to be bid up substantially. An example of such a resource adjustment problem would be one caused by a reduction in public grazing that affected many ranchers in a local area.

Many public range resource managers seem to be reluctant to want to study or learn anything about the ranch firm as part of their information base. The argument goes like this: we are range resource managers not ranchers or livestock managers, thus, we are not interested in the ranch business. This reasoning appears to have some faults. Knowing something about the ranch firm may not directly influence one's ability to manage the public rangeland, however, an understanding about the ranch firm's resource organization which shows how all land ownerships fit together to make a year-round operation may be beneficial to the resource manager. It also may benefit him to see why ranch firms are so concerned about resource management decisions that could impact their weaning weights and calf or lamb crop percentages. Marginal changes in these variables directly impact the rancher's income for family living expenses since the costs of the ranch operation must be paid first. The main point to be made is that the public rangelands can be managed in alternative ways that leave the land essentially the same but may have significantly different impacts on the ranch firm and ultimately on society's demand for food and fiber from these uses of the land. One point made earlier in this paper should be restated: all adjustment decisions in resource use must ultimately be made at the ranch firm level.

A related philosophy of public land management goes something like this: "I am a land manager not a rancher, lumberman, recreationist, wildlife manager or miner. Therefore, I am only interested in maintaining the land base in proper (nondeteriorating) condition for present and future generations." What's wrong with this philosophy of public land management? Public land policy statements usually have some reference to beneficial uses to be made of the land. In my opinion resource managers cannot divorce themselves from the uses made on the land. For example, two different resource use mixes could leave the land in the same biological

or physical condition, but one mix of uses could have economic and/or social benefits much higher than the other mix.

In summary, a basic understanding of the ranch firm as the decision-making unit within the range livestock industry is essential for one working in the area of range economics. Problems of aggregation from the ranch firm to the livestock industry still pose serious limitations for many research problems. Ranch budgeting is an important tool that should not be ignored when training students in several speciality fields related to range economics.

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THE USE OF LINEAR PROGRAMMING TO ESTIMATE RANGE FORAGE VALUES

C. Kerry Gee

ABSTRACT: The value of range forage for livestock production can be estimated with linear programming models. The usefulness of the resulting estimates is dependent upon the accuracy of data used in the analysis and upon the willingness of users of the estimates to accept assumptions implicit in this technique. This paper outlines limitations and benefits of using LP to estimate forage values.

INTRODUCTION

In October 1979 the Economic Research Service (ERS) of USDA entered into an interagency agreement with the Forest Service (USFS) to estimate forage values for livestock grazing Forest System rangelands including both National Forests (NF) and National Grasslands. Resulting values were to be used in forest planning. Since its inception, the project has generated values for 85 National Forests and National Grasslands. Estimated forage values have ranged from $.05 to $23.35 per animal month (AM). Values for 76 percent of the areas have fallen between $7.00 and $16.00 per AM.

The USFS-ERS contract specified that linear programming (LP) provide the analytical basis for estimation. Details of the methodology are published as a Colorado State University Experiment Station report.[1] General procedures are as follows:

1. Permittees are stratified by kind, type, and size of livestock enterprise.

2. Average enterprise cost and return budgets are prepared for each strata.

3. An LP matrix for each enterprise budget is constructed which will reproduce the budget exactly. Animal Months (AM) of USFS grazing appear as a single row in the matrix.

4. Marginal Value Products (MVP) for forest AM's in each enterprise budget are weighted by total Forest AM's for each strata to estimate a single forest forage value.

The correctness of forage values estimated through this procedure is dependent on the validity of assumptions associated with the LP, correct specification of the LP matrix, and accuracy of the enterprise budget data.

LP ASSUMPTIONS

The LP objective function in this project is defined as follows:

$$NR = \Sigma p_i q_i$$

where

NR = Gross sales minus all costs except interest on land and the forest grazing fee.

p_i = product prices and input costs.

q_i = quantities of products sold or inputs purchased.

The value of NR in the matrix solution can also be produced as follows:

$$NR = \Sigma S_i L_i$$

where

S_i = MVP's of each restricting resource in the LP solution.

L_i = Quantity of each restricting resource in the solution.

The second equation quantifies the contribution of each scarce resource to NR. The MVP for forest grazing measures the dollars added to NR by one AM (given the present size of herd, production, cost structure, and level of technology) or the forage value to the business which is the value needed in forest planning.

LP carries with it some assumptions that can affect forage value estimates:

1. Additivity and linearity--this precludes interaction between production processes and precludes economies of size or scale.

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[1] C. Kerry Gee. Estimating Economic Impacts of Adjustments in Grazing on Federal Lands and Estimating Federal Rangeland Forage Values: Colorado State University Experiment Station Tech. Bul. 143; November 1981. 11 pp.

2. Divisibility--which allows for fractional units of inputs and products.

3. Single valued expectations--all coefficients are known constants.

The first two assumptions should not be concerns in this project since the matrices are constructed to reproduce the current costs and returns for livestock businesses. No adjustments from current size of business or enterprise combinations occur in estimating forage values. The assumption of single valued expectations relates to the accuracy of matrix elements compared with actual performance of livestock businesses using forest rangeland. This does affect the MVP. If initial enterprise budgets are not representative averages of livestock businesses using a particular NF, the MVP will be incorrect.

SPECIFICATION ERROR

Construction of LP matrices in terms of number and kind of equations can affect forage value estimates. Interrelationships between scarce resources and production alternatives in livestock businesses that use forest grazing must be correctly specified. Annual feed sources must be incorporated to describe seasons of use and feed substitution alternatives used by producers. For example, the MVP may be much different for a resource if it is an only feed source in a given month than if it is available over several months and there are other feeds available during the same time period.

ACCURACY OF MATRIX ELEMENTS

As indicated above, accuracy of data is essential to reliable forage value estimates. It seldom occurs that all matrix elements in an LP analysis are known constants. In most cases they are best estimates, without even the benefit of confidence limits. Adequacy of data often is checked either by comparison with information (collected using similar procedures) from other studies or by the accumulated knowledge of the researcher. Accuracy of data is probably the principle concern in estimating forage values using linear programming.

ADVANTAGES OF LP IN FORAGE VALUE ESTIMATION

MVP's generated in LP analyses are sensitive to changes in matrix coefficients. Differences among forests in terms of feed costs, calving percentages, market weights of cattle and calves, livestock prices, etc., are all reflected by variations in estimated forage values. As indicated earlier, values generated in the USFS-ERS project thus far, have ranged from $.05 to $23.35 per AM. Reasons for differences among forests are explainable by reference to the enterprise budgets for the forests. For example, the extremely small value (on the Angelina National Forest of Texas) is low productivity--a calving rate of 70 percent, market weights on steer and heifer calves of 350 and 300 pounds respectively, and 700 pound cull cow weights resulting in gross sales per cow of $149. Sales on most forests in the southeast reach about $250 per cow. The high value (on the Chattahoochee National Forest) was due to a significant proportion of AM's going for dairy stock which affected both sales and costs.

Forage value differences frequently occur between forests in the same geographical area. Values for the Gallatin and Deerlodge National Forests, both in southwestern Montana were $8.66 and $16.95 respectively. A review of the enterprise budgets showed costs per cow about the same on both forests. However, total sales per cow were $274 on the Gallatin and $339 on the Deerlodge. High sales on the latter forest were caused by a higher proportion calves sold as yearlings, heavier market weights for animals sold, and a higher weaning percentage. Differences in LP generated forage values among forests can be explained. Factors found to cause differences among forests in the USFS-ERS project include:

1. Herd size distribution--values for large herds tend to be higher than for small herds.

2. Kind of livestock--sheep usually generate higher forage values than cattle.

3. Type of enterprise--yearlings usually have lower values than either cow-calf or cow-yearling enterprises and cow-yearling enterprises may have higher values than cow-calf enterprises.

4. Sales--high sales per cow may give higher forage values (costs must be checked also). Sales depend on type of enterprise, market weights, calving percentage, death loss, replacement rates, livestock prices, etc., any of which may be the explanatory factor for a difference between two forests.

5. Costs--high costs may cause low forage values (sales must be checked also). Cost differences may be due to amount of supplementary feeds fed, whether feed is produced or purchased, dependence on federal grazing land, labor requirements, etc.

6. Dependency on federal grazing land and season of use may affect forage values.

An important advantage of LP is that differences in livestock production among forests can

be incorporated into the analysis and reasons for differences in forage values among National Forests are identifiable.

SUMMARY

LP will produce forage values which represent the economic contribution of forest grazing to livestock businesses. It will produce values which show differences among forests in the value of this feed source to livestock producers. The correctness of estimated values depends on correct specification of the model and accuracy of the matrix coefficients.

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VALUING RANGE FORAGE ON PUBLIC RANGELANDS

E. T. Bartlett

ABSTRACT: Range forage is an intermediate good that is used to produce other outputs such as red meat, wildlife and associated recreational benefits, and wild horses and burros. Also, society places value on the continuity of range ecosystems and the plant species within those ecosystems. Value of forage grazed by livestock has been determined through: 1) comparisons with market-priced forages and feed sources; 2) capitalization of permit values; and 3) production analyses. Currently, production analyses offer the most promise in deriving demand for public range forage. Studies have been reported that determine value of wildlife and wildlife recreation; however, these values have not been related back to the habitat. Value of forage for wild horses and burros has not been studied by economists but valuation has been reflected in legislation. Agencies are mandated to provide for ecosystem continuity and diversity, but the value of these benefits has largely been ignored by researchers, managers and the budgetary process.

INTRODUCTION

Range includes both forested and non-forested lands which support an understory or periodic cover of herbaceous or shrubby vegetation amenable to grazing or browsing use (Range Term Glossary Committee 1974). Range, like other wildlands, provides many outputs such as recreation, water, forest products, wildlife, and related goods and services but has traditionally been associated with providing forage for livestock. The purpose of this paper is to examine the methods that have been used to determine value of benefits relating to range forage and to the ecological aspects of range resources, and to examine data needs for each method.

Most of the literature on range valuation has concentrated on the value of forage for grazing by domestic livestock and has been associated with grazing fee determination on public lands. One of the earliest studies was conducted in 1916 to determine the value of grazing on private range that was comparable to public lands (Dutton 1953). Numerous studies and recommendations have been made over the years. Godfrey (1981) recently reviewed research needs for forage valuation on range and cropland.

Goods and amenities will be defined in the following section with the concentration on those that use range forage. The approaches that have been used to estimate value of range outputs will be reviewed and examined with respect to usefulness in benefit-cost analysis and valuation of other resource uses or amenities. The final section discusses the data requirements of the different methods.

RANGE BENEFITS

When most people think of range, they imagine cattle grazing on a mountain meadow or a vast prairie. Indeed, range forage for the grazing of domestic animals has been and is an important use of range; however, other herbivores also use range forage. Range forage is an intermediate good that is used to produce other outputs such as red meat, wildlife and associated recreational benefits, and wild horses and burros. Finally, it appears that society places value on the continuity of the range ecosystems and the plant species within those ecosystems.

The amount and quality of range forage varies between ranges and temporally on the same range. In addition, the amount of forage available for grazing depends on the type of animal using that forage. The most common of domestic animals that are grazed on range are cattle. The next most numerous are sheep, although numbers of sheep have declined since the mid-1940's. Some domestic horses are grazed on most range, and goats are present on some ranges in the southwest. The amount of range forage used is dependent on the characteristics of the range, the stocking rate and the types of animals grazed.

Numerous species of wildlife occur on range and derive all or part of their habitat and nutritional requirements from native range. Some of the wildlife species compete for the range resource with domestic animals while other wildlife species might be thought of as complementary users of the range forage resource depending on the range ecosystem and season of use. Most wildlife production studies on range have concentrated on big game species such as deer and elk. Research is needed to determine the joint production relationships between different animal species when present during the same seasons or during different seasons. In fact, little work has been done to determine joint production relationships of different domestic animal species.

In addition to wildlife such as deer and elk, wild horses and burros are present on many western ranges. These animals compete for forage with both livestock and wildlife. While most people have not seen a wild horse or a wild burro, there is a benefit derived from them by society. This will be discussed further in a following section.

Non-use benefits of range include the continuity of the various range ecosystems and the continuing existence of species that are rare, threatened or endangered. Various legislation provides evidence that society places value on continuity of eco-

systems and species. And, in fact, the Public Rangeland Improvement Act of 1977 authorizes funds to improve rangelands without regard to use.

VALUATION OF RANGE FORAGE

The primary focus of the discussion that follows will be on the valuation of range benefits derived from grazing livestock. The valuation of the other benefits has not been prominent in the literature, and the valuations that have been made have been based on the income compensation function approach or the expenditure function approach (Randal 1981).

Domestic Livestock Grazing

Range forage is not a consumer good but an intermediate or producer good that is used in the production of products that are desired by man. It has been classified in resource economics as a market good, as opposed to a non-market good. This is a valid classification in the case of private range that is allocated to users by a market system. However, on lands administered by the USDA Forest Service (FS) and Bureau of Land Management (BLM), grazing has been allocated to those who met federal requirements to obtain grazing permits. Thus, public range was originally allocated on rules for obtaining a permit; however, permits are exchanged in the market system and reflect value above grazing fees.

The value of range forage grazed by livestock is derived from the value of the livestock produced. Thus, the value of range forage is dependent on the values of products produced from range forage, the value of other types of feeds and forage that might be used to produce the products, and the efficiency of the firm. The value of the range forage is the total amount that the firm would be willing to pay for the last increment of forage, or the value of the marginal product.

Several empirical approaches have been used in an attempt to identify the value of marginal product for range forage. The methods can be generally classified as: 1) comparisons with market-priced forages and feed sources; 2) capitalization of permit values; and 3) production analysis.

Comparisons with market-price forages and feed sources.--This approach is based on determining the value of substitutes for range forage in the production process, and adjusting the value for differences in the cost of using different forage or feed sources. The most closely related alternative forage resource has been comparable private leased range. Numerous studies have been conducted since 1916 with the 1966 Western Livestock Grazing Survey[1] and 1977 Study of Fees for Grazing Livestock on Federal Lands (Bergland and Andrus 1977) being the most recent.[2]

The premise that is used to justify estimating public grazing value from private grazing values is that firms will bid for both sources to the margin in which case the price of private grazing will equal the price of public grazing (Nielsen 1972). However, it has been shown that the rancher does not pay the full value for public grazing, and that he is not allowed to purchase federal grazing to the margin (Roberts 1963). The approach that has been used to derive an estimate of the value of federal range forage has been as follows:

$$F = MVP - E \qquad (1)$$

where F is the full market value of federal forage, MVP is the market value of the forage determined from private lease rates and E is the non-fee costs of using public ranges such as herding, improvement maintenance and transportation (Nielsen 1972). E adjusts the value to the net differences in using the public forage as opposed to the private forage.

The adjusted private lease rate was the basis for grazing fees from 1969 to 1978, and was recommended as the preferred method in 1977 by the Departments of Agriculture and Interior (Bergland and Andrus 1977). The 1977 study assumed that non-fee costs had increased at a constant rate since the 1966 survey. This assumes that the intensity of management has remained constant over this time period. In fact, many grazing systems were implemented on federal allotments since 1966 which intensified management and increased non-fee costs (Bartlett and Ralphs 1978).[3] This is not a weakness of the empirical approach, but a weakness in the application of the approach.

The private lease rate approach results in the value of range forage at the current level of use. If the value is used in cases where there are only marginal changes in the forage provided, the private lease rate approach can be used if the private range is comparable to the public forage resource (Dyer 1981). The need to use private range that is comparable to the public range is to include consideration of the quality of the range (forage quantity and quality, distributional factors such as water and topography) so that the animal productivity of the two range resources is comparable.

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[1]The author has not been able to locate a copy of the 1966 study, but it is summarized in Bergland and Andrus (1977).

[2]Land appraisers from the U.S. Forest Service and Bureau of Land Management are currently conducting a study on private land lease rates. This is to be completed in 1983.

[3]Bartlett, E. T. and M. R. Ralphs. Estimation of grazing values for the 1980 RPA program. Report of the RPA evaluation work group. Unpublished mimeo, USDA, Forest Service; 1978. 29 p.

It is possible that the private lease rate approach could be expanded to estimate demand for public range forage. The derived demand would then be adjusted to reflect demand for public range forage. There has been no study that has attempted such an approach (Godfrey 1981), although Johnson and Hardin (1955) discussed the factors that effect the demand for pasture forage.

Other forage sources such as pasture, hay or supplemental feeds have been suggested as points of measurement in efforts to estimate range forage value. The use of pasture lease rates would be very similar to the private lease rate described above; however, the problems involved in relating pasture values to range values would be greater. Pastures are generally much higher in productivity than range, and are intensively managed in small units.

The value of hay has been used to estimate value of range forage (USDA Forest Service 1980, p. C-6). A formula was used that multiplied the average animal weight times the average price per ton of hay times a quality factor of pasture. Hay is exchanged in a competitive market and as such reflects the changes in livestock values and other feed source values (Godfrey 1981). Empirical evidence could not be found that relates hay to range forage.[4] A general caution concerning methods that are based on alternative feed sources is that the market price of a substitute is not a good proxy for range forage value, but substitute feeds do influence the demand for range forage.

Capitalization of permit values.--Historically the fee for grazing public range forage has been below the value of the range forage.[5] Because the marginal value of the public forage exceeded the marginal costs of using it, the permits have accrued value. The permit value is the capitalized difference between the marginal revenues and marginal costs. Roberts and Topham (1965) give the value of public range as:

$$V = F + PC \qquad (2)$$

where V is the annual value of public forage to ranchers, F is the grazing fee, P is the market value of the grazing permit, and C is the capitalization rate.

[4]The author could not obtain a copy of the original study on which this formula was based. One can only assume that it was derived by some statistical method.

[5]For a discussion of the history of grazing fees on public range, see Dutton (1953), Foss (1959) and Bergland and Andrus (1977).

Several studies have tested the permit value equation (Gardner 1962; Roberts and Topham 1965; and Martin and Jefferies 1966). Gardner (1962) used an expectation model to estimate the difference between private and public grazing charges. The difference was capitalized to represent the expected value of the permit. Actual permit values were well below the expected permit values. Gardner argued that this was due to the restrictive rules for qualifying for a permit, and the history of reducing permitted grazing when allotments were reassigned. Roberts and Topham (1965) stated that the fee plus the discounted value of the permit was a good estimte of the value of public forage at the site.

Martin and Jefferies (1966) used regression analysis to estimte the price of ranches as a function of acres of private land, animal units of FS permits, animal units of BLM permits, animal units of state permits, number of breeding animals, steers and heifers sold with the ranch and the year the ranch was sold. Marginal value was estimated for FS and BLM permits. Estimated values exceeded values that would be expected based solely on cattle production.

Martin and Jefferies (1966) hypothesize that there are other returns besides beef production to the permit investment. These include anticipated appreciation in permit value, reduced taxes through tax shelters, ranch fundamentalism and conspicuous consumption. Ranch fundamentalism refers to those that place some value on being in the livestock business and on that way of life while conspicuous consumption refers to those that buy ranches because one who lives in the west should have a "ranch". The argument is that permit values represent benefits in addition to those gained from grazing range forage for livestock production.

If the above argument is true, why were Gardner's expected permit values so much higher than actual values? Martin and Jefferies (1966) state, "The outputs of private rental lands are just as complicated as the outputs on public leases. One should not use private rental land as a standard for comparison, with the implication that private rentals are used for beef production only." Private lease rates may also be influenced by the season in which they are grazed. It is logical that a rancher would lease additional private range only at times when his deeded and public range were limiting. Thus, the values of private leased range may be higher because of the critical nature of the forage in a particular season. In Colorado, for example, changing the amount of spring grazing on public ranges had a much greater impact on livestock sales than changing the amount of grazing in other seasons (Cook and others 1980).

Another explanation of why expected permit values exceed actual values is that the permit value is reduced by the tenure uncertainty associated with permits (Milliman 1962). A recent study in New Mexico shows that while FS and BLM permits have increased in value from 1965 to 1979, the private grazing price index increased at a greater rate (Fowler and Gray 1980). In fact, neither BLM nor FS permits increased in value at a rate equal to the U.S. consumer price index, and BLM permit

value has not increased since 1975 when the grazing Environmental Impact Statement process was started. Thus, uncertainty of permit tenure does influence permit values. In Oregon, Winter and Whittaker (1981) did not find that public grazing rights were statistically related to private-land sale prices during 1970 to 1978. They explained the lack of permit value as being brought about by increasing grazing fees and uncertain tenure of permits.

Another factor that could influence the permit value is option value. Option value is the value in addition to the value of the resource that arises from retaining an option to use the good or service for which future demand is uncertain (Krutilla and Fisher 1975). Ranchers may stock their own range resources conservatively in normal years, and rely on the public range forage at permitted amounts or less than permitted amounts. In periods of forage shortage, they could rely on both resources to survive such periods. Studies using this approach have not been reported in the literature.

To summarize, it has been shown that public range grazing fees have been below the range forage value and that value has accrued to the permit. However, it is questionable that the short-term marginal value productivity of range forage for grazing is equal to the permit value. Permits are issued for ten years so there is a long term value possibly related to an option value. In addition, permits may increase or decrease in value independent of the forage value. In any event, an estimate of range forage value based on permit value results in an estimate of value for the current level of forage provided. To derive demand, estimates at different levels of forage would be needed. However, it is doubtful that such a derived demand would be very useful as changes in permitted use affect the value of the permit due to uncertainties in tenure that are implied. The examination of permit value does give rise to many questions concerning range values.

Production analysis.--Production analysis is an approach (or group of approaches) in which an input is valued on the basis of the production process and resulting value of the output(s). There are basically two ways to approach the problem: 1) empirically estimate the production function, or 2) use operations research to model the relationships based on budget data.

Roberts (1963) suggested that a third-degree polynomial would be appropriate for a public forage production function based on grazing intensity.

$$R = bX + cX^2 - dX^3 \qquad (3)$$

where R is the total physical output times the market price of the livestock realized off the range, and X is the number of cows grazed per section (representing grazing intensity). From this, Roberts derived the MVP of grazing intensity. Most ranges are not stocked considering such a relationship, but are generally stocked at a moderate intensity level.

In the budgeting technique, the total gross value of the firm's output is calculated, and the costs of all variable inputs except range forage are then deducted. The remaining portion of gross value is known as the residual. It is the return to, or value of, the unpriced input (Sinden and Worrell 1979). If the residual is calculated for several amounts of the unpriced input, a demand schedule can be estimated.

The results obtained by budgeting are based on an implicit production function that is contained within the budget and estimate short-run value. Martin and Snider (1980) derived short-run values of range forage in the Salt-Verde Basin of Arizona using a budgeting approach. They also estimated the average and marginal long-run values of range forage by deducting fixed costs from the residual and capitalizing the remainder. This budget study is unique in that forage value was estimated; most budget studies merely report the economic characteristics of range firms.

Linear programming is a technique that has been used to analyze budget data. The residual of the marginal unit of input is known as the shadow price in linear programming jargon. Parametric analysis in which the amount of range forage is varied can be used to calculate the residuals which represent the demand for the unpriced input. This technique has been used to derive demand for FS forage in Colorado (Bartlett and others 1981). The demand was estimated for various livestock prices and under two management schemes: variable herd size and constant herd size. The constant herd size resulted in a demand based on the costs of alternate feed sources while the variable herd size scheme allowed adjustment of inputs and products.

The Economic Research Service is currently using budgeting and linear programming to estimate the marginal value of public range forage in the western U.S.[6] There have also been a number of studies that have assessed the impacts of potential changes in public forage supply and cost on net ranch income, livestock sales and local and regional economies (Peryam and Olson 1975; Olson and Jackson 1975; Lewis and Taylor 1977; Torell and others 1979; Torell and others 1980; and Cook and others 1980).

While linear programming provided a technique to rapidly analyze budget information and derive demand for range forage, results are based on the budget data and the assumptions incorporated with the linear programming model. Budgetary information is rapidly outdated because of changes in operation caused by changing market prices for outputs and technology (McConnen 1976). Values obtained with the uses of linear programming analysis are determined by changes in other inputs, and other resources are valued and reflected in the measurement of any given factor or resource (McCorkle 1956). In fact, it is difficult to

[6]This study is led by Dr. K. Gee and has been supported by the USDA Forest Service and Bureau of Land Management, USDI.

compare the results of various studies unless the linear programming models have been formulated in a similar manner. A set of common assumptions and model formulation rules are needed so that valuation studies are consistent.

Godfrey (1981) mentions five weaknesses that cause linear programming to be biased and not comparable to estimates derived for other benefits. Three of these weaknesses relate to how ranch budgets are modeled, and can be resolved. Another of Godfrey's assumptions is related to the theoretical validity of deriving demand from a fixed proportion production function, which he admits is not a major problem. However, a completely fixed proportion model would result in a linear production function and horizontal demand. This is an area in which recommendations are needed to guide future use of linear programming. Finally, Godfrey (1981, p. 42) states, ".... and perhaps most importantly, the demand function derived from an LP model is generally very sensitive to changes in the price of the output(s) and/or other inputs." This is not necessarily a weakness of using linear programming, but shows that the estimates of forage demand are, in fact, sensitive to the demand shifters.

Other valuation approaches.--Other studies have been made to determine the value of public grazing. Most of these have been done to estimate grazing fees for state-owned range forage and are based on livestock prices and various other factors including carrying capacity (Huss 1955; Harris and Hoffman 1963; Campbell and Wood 1951; and McDowell and Johnson 1964). Most of the results were based on what was acceptable to the leasor and leasee and were not based on empirical estimates of the value of range forage.

Approaches that are used to estimate non-market benefits such as recreation have not been applied to range forage. However, there is a study at Colorado State University that will use a bidding game approach to estimate public range forage value. The resulting values will be compared to those estimated with a linear programming approach (Bartlett and others 1981).

Value of Wildlife Use

Wildlife compete for the same resource base that is used by domestic livestock. Wildlife uses are classified as consumptive, non-consumptive, and indirect or vicarious users of wildlife (Shaw 1982). These uses have been valued by the income compensation function approach or the expenditure function approach as described by Randall (1982). However, these values have not been related back to the habitat that the animals need in order to produce the various wildlife benefits.

Wildlife management programs do influence the amount of wildlife and domestic animals that will be present although there is disagreement on how the resource can be allocated to different animal species. However, range forage for domestic grazing is valued on the site and at the margin. Therefore, recreational values of wildlife should be traced back to a comparable basis in order to provide information concerning the efficiency criterion to decision makers. Admittedly, this is not an easy task, especially since little has been reported on the joint production functions of different species of animals using the same resource base.

Wild Horses and Burros

While wild horses and burros have long been a common feature of many western ranges, their value was largely ignored until the passage of the Wild Free-Roaming Horse and Burros Act of 1971. The bill essentially dictates that the horses and burros will not be disturbed by man; society valued their existence even though most members would never actually observe the animals. The original bill implies a high value since few herd control measures were allowed (Cook 1975). Provisions in the Federal Land Policy and Management Act of 1976 and the Public Rangelands Improvement Act of 1977 modified the control measures allowed and indicate that society values wild horses and burros less than originally thought.

Godfrey (1979) reviewed the wild horse and burro question and found that very little is known of the value. Godfrey has determined the expenditures being made to reduce herd numbers which does not estimate the demand for the animals but might reflect some minimum value that society places on ecosystems being grazed by wild horses and burros. Johnson and Yost (1979) reviewed economic literature that related to wild horses and burros, and reported very few studies or articles on the subject. Suffice it to say that research is needed to determine the existence value of these animals.[7]

Ecological Continuity

Krutilla and Fisher (1975) define existence values as value that individuals have for an environment regardless of the fact that they will never demand *in situ* the services it provides. Society values the existence of range ecosystems or the option value of saving them for use in the future. This benefit of range has not been estimated empirically. To date, this benefit, as well as the benefits from rare and endangered species, have been assured through legislation. Legislation has mandated agencies to provide for ecosystem continuity and diversity as well as to make efforts to insure the survival of limited animal and plant species. Given the present state-of-the-art, demand estimates and marginal values of these benefits are not expected to be forthcoming.

The relation between ecological continuity and other range benefits should be evaluated. Environmental quality may be maintained or improved with proper and moderate livestock grazing

[7]The Bureau of Land Management was at one time going to issue an RFP for such a study; however, to my knowledge, it was never issued.

(Council on Agricultural Science and Technology 1974). In the management and planning of wildlands, program costs should be allocated to the benefits for which they are implemented.

DATA REQUIREMENTS

Although various range benefits have been discussed, past work has been limited almost exclusively to valuing range forage for livestock production. All methods for forage valuation for livestock production require considerable data collection. In comparisons with market-priced forages and feed sources, privately leased forage is the most appropriate forage source. Currently, land appraisers of the USFS and BLM are appraising private lease rates as part of the 1985 Grazing Fee Study required by the Public Rangeland Improvement Act of 1978 (PRIA). This study will be completed in March, 1984 at a cost of $2.8 million. While the 1966 Western Livestock Grazing Survey used mail questionnaires, the appraisal study is attempting complete enumeration of all range forage leases comparable to public rangeland.

In any study of leases, the basis for the lease must be determined. The FS and BLM charge on an AUM basis, but other leases (private and public) are based on acreage, number of head, rate of gain, or animal units as well as AUM's. Even if AUM's are used, the definition from lease to lease is variable. Therefore, the researcher must exercise care to adjust all leases to a common basis for comparison purposes, and to estimate averages.

Services provided by the leasor and leasee also vary. Updates of the 1966 Western Livestock Grazing Survey were based on lease rates alone, assuming factors affecting the lease rate remained constant. The factors affecting the private lease rate must at least be examined periodically. Lease rates are influenced by the value of services provided by the leasee and leasor, the nature of the forage resource, size of the lease, location, term of lease, characteristics of the leasee's livestock operation, and other uses. Grazing leases include various services other than the use of range forage. Those services and their value must be determined to estimate the value of the forage. Services often ignored are range improvements that have been provided by either the leasee or leasor. A record of past improvements or future improvements required by the lease must be obtained in order to determine the annual value of the forage.

Characteristics of the rangeland and forage that influence value include quantity of forage, quality of forage, topography, water supplies and seasonal availability for grazing. Most range scientists feel that quantity and quality of forage must be strong determinants of forage value. However, the many other factors affecting forage value seem to mask these influences. Topography and season of use interact to influence grazing value. Rugged summer range causes increased livestock handling costs, but broken topography on winter ranges provides protection for livestock. Topography also influences suitability of ranges for different types of livestock.

The size, location and term of grazing leases also influences lease rates, and information is required on each. The conditions of the lease may also provide for an option for renewal on the term of the lease.

Many of the above factors interact in the ranch operation. The value of forage from a particular range is dependent on how that resource is incorporated with other resources of the ranch using the forage. Production analysis is required to determine the relationships between the resources to produce livestock. This is usually not done in lease studies, but does influence lease rates. In fact, this probably explains why ranges that are very similar in quality and quantity of forage lease for different amounts and why ranges vastly different in productivity lease for the same rate.

In order to capitalize permit values, those values must be determined through analysis of ranch sales or appraisals. A survey of ranch sales can be made in which the permit value is determined, or land appraisers can be interviewed to determine estimates of land sales (Fowler and Gray 1981). The former is based on examination of actual land sales but is relatively expensive. Also, ranch sales may be few for a particular area and year. Fowler and Gray (1981) interviewed land appraisers in New Mexico, and relied on the appraisers' knowledge of land and permit values rather than actual sales. In addition, the appraisers were asked to assess the values over the past decade which allowed comparison of value trends of different range resources.

Characteristics of the range associated with permit sales may influence permit values. Additional data collection would be needed in surveys of actual ranch sales.

Production analysis methods require the most extensive data collection as range forage is but one input in livestock production. Ranches are sampled and ranch budgets determined. These budgets need to be detailed so that production relationships can be determined. Ranch budgets can then be used to formulate linear programming approximations of the production processes. Information on alternative feed sources, seasonal availability of forage, livestock prices, and range capacities as well as livestock parameters is needed, but it is not evident how these parameters should be manipulated within the linear programming models. A study by a group of scientists should be made that would result in a set of guidelines for using this approach so that values are consistent and comparable between geographical areas and across different groups or individuals that use the technique.

All methods require a sample or complete enumeration of a population, and care must be used in identifying that population and the frame. In addition, appropriate experimental design is

required in sampling, stratification and survey instrument design. Actual surveys have been done by phone, mail, and personal interviews.

Both the appraisal study and the survey of government leasing policies being done by Colorado State University use personal interviews. The quality of data is usually higher with personal interviews, if the interviewers are knowledgeable and well-trained, and clarification of questions is facilitated. In the past, a sample survey has been made of livestock operators; however, many of those sampled did not lease grazing and responded on hearsay knowledge. In addition, enumeration may be required where public land dominates and few private leases exist.

Regardless of what method is used to value forage, revaluation is needed over time. Theoretically it would be possible to do studies annually. But, this is unrealistic due to cost and time constraints. Therefore, some annual updating must be done on indexing basis with complete periodic updating of the value.

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OPPORTUNITIES FOR THE MORE INTENSIVE USE OF INPUT-OUTPUT ANALYSIS IN PUBLIC RANGELAND DECISION-MAKING

Frederick W. Obermiller

ABSTRACT: Numerous opportunities for the more intensive use of input-output methodology in public rangeland and forestland research and decision-making exist. Some of these opportunities, as well as useful and operational extensions of the static methodology, are described. Literature relative to the topic is highlighted.

INTRODUCTION

Input-output analysis essentially is a form of income accounting which has well established roots in macroeconomic theory. The technique has been extensively used, and perhaps almost as extensively misused, in range and forest economics research and related applications. Unfortunately, economists have provided input-output model users and decision-makers with something less than thoughtful guidance in the development, modification, and application of input-output methodology.

This paper addresses some, but by no means all, of the deficiencies in development and application of regional (substate) input-output models. A common theme in the paper is the application of such models to natural resource management and related policy issues, with special emphasis on public rangeland resources. The paper consists of three parts. First, the role of input-output analysis in the issue area is justified. Second, opportunities for more comprehensive use of conventional static models are described. Third, useful operational modifications of existing models are presented. An attempt is made throughout the paper to identify recent literature of relevance, for the topic addressed is far too broad and complex to be treated in depth here.

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JUSTIFYING THE USE OF INPUT-OUTPUT ANALYSIS

The use of input-output models in range and forest economics research, or more generally in natural resource management and policy analysis, has been widespread. Despite the technique's major conceptual and empirical limitations, and despite the reservations expressed by some economists, e.g., Smith and Martin (1972), Dyer (1981), static input-output models remain one of the most widely used--and often abused--techniques in regional economic impact analysis.[1] Further, values derived from input-output models, especially estimates of secondary (indirect and/or induced) income impacts, sometimes are used in project or economic feasibility studies, especially in benefit-cost analysis--to the consternation of some economists and delight of some special interest groups.

In an empirical sense, the static input-output model's major limitation is its data intensity. Questions of statistical error and response bias aside, construction of primary data models--even for relatively small regional economies--may be both time consuming and expensive:[2] an observation used to justify the use of secondary data models by the Forest Service (Alward and Palmer). The alternative approach, typified by the Forest Service IMPLAN system, uses secondary data to develop static models from the national input-output model constructed by the United States Department of Commerce (1979). Such secondary data models are based on highly questionable assumptions (Czmanski and Malizia 1969; Schaffer and Chu 1969; Miernyk 1976) which when tested have been shown to produce regionalized models whose coefficients differ markedly from those

[1] Recent surveys of the extent of use of input-output analysis as applied to natural resource (range and forest) management and use issues are provided by Godfrey (1981), Eppley (1982), and Alward and Palmer, among others. Godfrey, and also Kearl (1980) and Martin (1981) discuss many of the more common misapplications and misuses of the technique, most of which are attributed to the naivety, inexperience, and/or training deficiencies of personnel applying input-output methodology.

[2] In Oregon, for example, county-level primary data models developed over the past two years have, on average, cost approximately $10,000 - $12,000 to construct; and have taken about nine months to complete.

revealed using primary data methods for the same or similar regions (Carroll, 1980; Keith, 1982); although Boster and Martin (1972) offer contradictory evidence. These recognized problems notwithstanding, the secondary data approach to construction of static input-output models typically is justified on the basis of the relative efficiency argument in conjunction with agency policy to use uniform data sets in model development and application.[3]

Perhaps more troublesome than empirical constraints and the debate over the veracity of secondary data models are two basic assumptions underlying both the conceptual structure and application of static input-output models. These are: (1) the assumption that all firms in a given sector of the economy produce a single homogeneous output and share a fixed factor proportion production function which is homogeneous of degree one, ruling out external economies or diseconomies, joint products, and multi-product firms; and (2) the assumption that the economy being modeled is in equilibrium, implying that the composition of endogenous demand for a sector's output, relative prices, trading patterns, and technology are all constant (Boyle and Obermiller, 1982). While the second assumption generally applies to the other major techniques--including most forms of linear programming, benefit-cost analysis, and budgeting--used in range and forest economics research, the first assumption places input-output methodology at a singular disadvantage in the valuation of nonmarket resources, the thrust of natural resource economics research over the past decade.

Why, then, are static input-output models so widely applied to problems involving the allocation and development of forest and range resources? Several explanations may exist, but two are paramount. First, input-output models provide a wealth of information on the regional distributive impacts of exogenous disturbances--information generally not provided by econometric or linear programming models, information not contained in the generalized NED (i.e., national perspective) approach to benefit-cost analysis, but information required by the statutes governing the public land use decision-making process (Obermiller and Boyle, 1981; Obermiller, 1982b). Second, the input-output approach is exceedingly postive. The neoclassical assumptions of profit maximization, consumer utility maximization, and resource allocation through perfect markets are not used: The economy is described as it is rather than as it should be under the imposed structural and behavioral assumptions.[4]

The first of these two explanations gains in importance to the extent that income distribution is, for whatever reason, the crux of the public land use debate and may be in the process of becoming a central problem in applied welfare economics. Following Bromley (1981): "It does very little good to offer as a goal a construct which--for a variety of reasons--cannot produce the answers as to which interests ought to receive the income streams from public lands" (p. 11). And, "...in public land management, there is no unambiguous metric whereby we can know relative values of many of the goods and services which flow from the public lands" (p. 3). Bromley's comments may be interpreted as (1) skeptical of the ultimate success of generalized or idealized benefit-cost analysis (Workman, 1981, pp. 9-16) and hence of at least some nonmarket valuation methodologies (Howitt, 1981, pp. 1-3); while (2) lending support to the use of input-output techniques in range and forest economics research--not that the methodology answers the normative question posed by Bromley, but rather, as noted above, it provides the positive distributive information to be weighted by the decision-maker(s) in formulating his or her social welfare function.[5]

The comparative strengths, or advantages, of input-output analysis invite its more extensive use in public land planning, management, and decision-making. Concurrently, efforts to reconcile primary and secondary approaches to model development and application, and to relax the conceptual limitations underlying the static approach, are warranted. Some of these opportunities are reviewed below.

OPPORTUNITIES FOR EXPANDED USE OF TRADITIONAL REGIONAL MODELS

Possibly the most serious failing of input-output model users is the tendency to concentrate simply on applications of gross output multipliers derived from the Leontief inverse matrix to the exclusion of the wealth of descriptive, and at least casually analytic, information also contained in the transactions and direct coefficients

[3]In the following discussion, emphasis is placed on the distributive information provided by static input-output models. Keith (1982) notes that such distributive information, if based on coefficients generated from non-survey techniques and secondary data models, may result in gross errors relative to partitive-based analysis using primary data models. The example used in this discussion is a primary data input-output model.

[4]Little, Mishan, Weisbrod, Robbins, Hicks, Chipman and Moore, and others have noted that these assumptions prescribe both behavioral activity and conditions of exchange in a conceptual marketplace, and hence contain implicit value judgments. Thus, when the neoclassical paradigm is used in policy analysis, and/or as a basis for policy recommendations, the construct's arguments are at best conditionally positive, if not entirely normative, in content. An equivalent critique can be made, of course, of any construct. For a review of relevant literature see Obermiller and Wear (1982, pp. 16-28).

[5]A recent survey of this literature is provided by VanKooten (1982). See also Workman, loc cit.

matrices. For example, sectoral and regional net trade balances can be derived from the transactions matrix as in table 1 below (see Obermiller and others 1981). The net trade balance may, in turn, be expressed as a percent of a sector's or the region's value of total gross output--a strong indicator of the extent to which the sector is basic to the economy, and/or factor markets in the regional economy are structurally developed.

Seldom is use made of the direct coefficients, or A, matrix. This is particularly unfortunate because it is within this matrix that the fixed factor proportion production and average cost functions are captured. Drawing from the A matrix, differences in the production and/or cost relationships characterizing, for example, public land dependent ranchers versus nonpermittees in the same region can be compared as in table 2; and significant differences can be subjected to further evaluation. Moreover, the direct coefficients matrix is useful in summarizing both the

Table 1. Value of total output, exports, imports, and net trade balances among sectors of the Baker County, Oregon, economy in 1979.

	Total gross output		Exports & imports		Net trade balance	
Sector	Value ($000)	Percent of total output	Export value ($000)	Import value ($000)	Value ($000)	Percent of total gross output
1. Dependent ranching	12,321	2.7	8,725	1,329	7,396	60.0
2. Other ranching	7,881	1.7	3,226	1,805	1,421	18.0
3. Other agriculture	6,108	1.3	2,277	556	1,721	28.2
4. Food processing	5,710	1.2	2,920	1,025	1,895	33.2
5. Timber harvesting & hauling	8,676	1.9	2,366	1,621	745	8.6
6. Lumber & wood products processing	32,451	7.0	22,021	9,860	12,161	37.5
7. Agricultural services	11,573	2.5	2,874	7,645	-4,771	-41.2
8. Mining & mineral products processing	15,389	3.3	11,348	10,097	1,251	8.1
9. Construction	31,499	6.8	5,503	13,908	-8,405	-26.7
10. Transportation	12,414	2.7	3,411	7,077	-3,666	-29.5
11. Communications & utilities	14,563	3.2	5,518	9,586	-4,068	-27.8
12. Finance, insurance, & real estate	23,953	5.2	4,810	15,676	-10,866	-45.4
13. Automotive sales & services	22,661	4.9	5,447	13,012	-7,565	-33.4
14. Professional services	8,413	1.8	721	2,344	-1,623	-19.3
15. Lodging	2,103	0.5	1,559	283	1,276	60.8
16. Cafes & taverns	7,875	1.7	5,243	1,882	3,361	42.7
17. Wholesale & retail trade	62,847	13.5	6,756	43,856	-37,100	-59.0
18. Other wholesale & retail services	3,425	0.7	100	731	-631	-18.4
19. Households	120,839	26.0	34,251	23,654	10,597	8.8
20. Bureau of Land Management	947	0.2	947	323	624	6.6
21. U.S. Forest Service	21,083	4.5	21,083	16,962	4,121	19.5
22. Local government	22,616	4.9	11,938	4,508	7,430	32.9
23. Local agencies of state & federal government	8,878	1.9	6,905	1,118	5,787	65.2
Subtotal	464,315	100.0	169,948	188,875	-18,927	-4.0
Local investment by nonlocal business	11,859					
Baker County Total	476,174					

Table 2. Differences in the production and cost functions of permittees versus other ranchers as reflected in their direct purchasing coefficients, Baker County, Oregon, 1979.

Sector from which purchases are made	Direct purchasing coefficients		
	Permittees	Nonpermittees	Permittees as % of nonpermittees
1. Dependent ranching	.05923	.06129	97
2. Other ranching	.05826	.07150	81
3. Other agriculture	.01919	.02149	89
4. Food processing	.03560	.02410	148
5. Timber harvesting & hauling	0	0	---
6. Lumber & wood products processing	0	0	---
7. Agricultural services	.10982	.11491	96
8. Mining & mineral products processing	0	0	---
9. Construction	0	0	---
10. Transportation	.03095	.01263	245
11. Communications & utilities	.01189	.01203	99
12. Finance, insurance, & real estate	.13046	.11849	110
13. Automotive sales & service	.00030	0	NA
14. Professional services	.00787	.00196	402
15. Lodging	0	0	---
16. Cafes & taverns	0	0	---
17. Wholesale & retail trade	.07954	.08768	91
18. Other wholesale & retail services	0	.00005	NA
19. Households	.20583	.17630	117
20. Bureau of Land Management	0	0	---
21. U.S. Forest Service	0	0	---
22. Local government	.02448	.01677	146
23. Local agencies of state & federal government	0	.00038	NA
Subtotal - All Local Sectors	.77342	.71957	107
24. Nonlocal households	0	.00004	NA
25. Nonlocal government	.02949	.02927	101
26. Nonlocal business	.07816	.19990	39
Subtotal - All Nonlocal Sectors	.10765	.22921	47
27. Inventory depletion	.06519	0	NA
28. Depreciation	.05179	.05221	99
TOTAL - ALL SECTORS	.99805	1.00100	NA

dependency of various sectors on local suppliers, and the extent to which each such sector generates value-added through purchases from local households, as in table 3.

The transactions and Leontief inverse matrices can be used in tandem to describe the final contribution of each local sector to a region's economy, taking into account both its final demand sales and its degree of interdependency with other local sectors. These calculations are especially useful when compared with initial sectoral contributions to local economic activity as in column two of table 1. For example, the calculations appearing in table 4 show that, in Baker County, Oregon, the actual contribution of all ranching to total value of gross local output was 9.5 percent in 1979, not 4.4 percent as might have been concluded from a cursory reading of the transactions table alone.

Input-output models commonly are applied to a direct or extrapolated change in value of livestock or wood product exports attributable to a public land management agency action.[6] Too often, the corresponding impact on total gross business activity and/or total household income is calculated, but the distribution of those income effects among local sectors and local households--one of the two major strengths of the technique--

[6]These applications are a routine part of the environmental impact statements prepared by the Bureau of Land Management and Forest Service. Other published applications frequently referenced in the literature on the subject include Bromley and others (1968); Bartlett and others (1979); and Torell and others (1980).

Table 3.--Percentages of total purchases from all local sources and from local households by sector of the Baker County, Oregon, economy in 1979.

Sector	Percent of total purchases from all local sectors	Percent of total purchases from local households
1. Dependent ranching	77	21
2. Other ranching	72	18
3. Other agriculture	84	18
4. Food processing	81	12
5. Timber harvesting & hauling	69	25
6. Lumber & wood products processing	44	24
7. Agricultural services	32	15
8. Mining & mineral products processing	31	26
9. Construction	54	21
10. Transportation	40	14
11. Communications & utilities	32	26
12. Finance, insurance, & real estate	34	29
13. Automotive sales & service	40	21
14. Professional services	69	55
15. Lodging	77	36
16. Cafes & taverns	73	32
17. Wholesale & retail trade	28	14
18. Other wholesale & retail services	75	45
19. Households	80	1
20. Bureau of Land Management	66	58
21. U.S. Forest Service	19	10
22. Local government	80	42
23. Local agencies of state & federal government	87	79
BAKER COUNTY TOTAL	56	20

is ignored. As is seen in table 5, an initial $400,000 decline in exports by the dependent ranching sector would have resulted in about a one million dollar decrease in value of local business activity, of which about $191,000 would have been foregone income to local households (value-added). Of this amount, 46 percent or $87,600 would have been lost income to dependent ranch households, an estimate obtained by multiplying the direct loss ($81,808) by the appropriate diagonal value from the Leontief inverse matrix. The remaining $103,200, or 54 percent of foregone household income, would have been lost by Baker County households not directly involved in public land dependent ranching--a measure that helps explain the degree of local community interest in public land use decisions.

Although it is infrequently done, values such as these may be accurately depicted in a number of ways.[7] In the present example, the change in value of livestock exports was simulated, using primary data, based on a proposed reduction of 10,589 AUMs of public grazing. From the viewpoint of county-wide business activity, the proposed grazing reduction would have resulted in a gross revenue loss of $102 per AUM, or $40 per AUM to the dependent ranching sector alone. Net (household or value-added) losses would have been $18 per AUM county-wide, or $8.27 per AUM to affected permittees. Deducting labor, management, permittee-financed allotment improvements, and applicable noncash costs from the $8.27 estimate would yield the derived average value of an AUM of public land forage to Baker County permittees--an operational alternative to the present method of establishing grazing fees (Obermiller and McCarl 1982). Capitalization of that residual value and the $8.27 estimate would bracket the average permit value in Baker County, and capitalization also could be used to extrapolate the sectoral or regional opportunity costs of public grazing or timber harvest reductions (Obermiller 1980a).

Still other applications of static models, applications requiring no further revision of existing models, are feasible. While the example employed above is negative in the sense that the initial stimulus is a proposed reduction in federal grazing, the same approach can be, and has been, used in analyzing the income effects of increased grazing or timber harvest. As in the instance of AUM reductions, increases in export sales of

[7]For a related application to forest use issues, specifically wilderness area additions, see Obermiller (1980b).

Table 4.--Contribution of final demand sales by each sector of the Baker County, Oregon, economy to total county business activity in 1979.

Sector	Value of final demand sales ($000)	Business income multipliers (Type II)	Value of direct & indirect business activity ($000)	Percent total county business activity
1. Dependent ranching	10,622	2.73	28,998	6.33
2. Other ranching	5,636	2.59	14,597	3.18
3. Other agriculture	2,389	2.73	6,500	1.42
4. Food processing	2,920	3.08	8,994	1.96
5. Timber harvesting & hauling	2,366	2.55	6,033	1.32
6. Lumber & wood products processing	31,799	2.11	67,096	14.63
7. Agricultural services	4,621	1.75	8,087	1.76
8. Mining & mineral products processing	12,797	1.77	22,651	4.94
9. Construction	14,691	2.20	32,320	7.05
10. Transportation	3,461	1.84	6,368	1.39
11. Communications & utilities	5,551	1.77	9,825	2.14
12. Finance, insurance, & real estate	6,745	1.83	12,343	2.69
13. Automotive sales & service	7,062	1.87	13,206	2.88
14. Professional services	940	2.65	2,491	0.54
15. Lodging	1,559	2.68	4,178	0.91
16. Cafes & taverns	5,255	2.78	14,609	3.19
17. Wholesale & retail trade	8,547	1.64	14,017	3.06
18. Other wholesale & retail services	124	2.76	342	0.01
19. Households	37,412	2.52	94,278	20.56
20. Bureau of Land Management	947	2.61	2,472	0.54
21. U.S. Forest Service	21,083	1.51	31,835	6.94
22. Local government	11,938	2.93	34,978	7.63
23. Local agencies of state & federal government	6,974	3.19	22,247	4.85
BAKER COUNTY TOTAL[1]	205,430	2.26	464,315	100.00

[1]The reported totals are correct but may not equal column sums due to rounding error.

livestock or forest products corresponding to increases in primary input supplies must be extrapolated.

The models are amenable to tradeoff analysis as, for example, in evaluating the relative distributive impacts of changes in recreational vis-a-vis livestock grazing land uses at the regional level, or similarly the extent to which income gains attributable to improved riparian and/or wildlife habitat offset losses caused by AUM or allowable cut reductions. Such applications are especially useful when making public land allocation decisions for they provide information on the relative primary and secondary income impacts of alternative use allocations--valued using a consistent methodological framework.

Clearly, applications of existing, unmodified, static input-output models to forest and rangeland resource issues are manifold. Only a few have been mentioned. The failure of model users to exploit these potentials, while understandable given the training and background of typical users, does considerably less than full justice to what Drucker (1981) has called "...one of the most advanced tools of modern economics, input-output analysis" (p.5).

OPERATIONAL MODIFICATIONS OF POTENTIAL VALUE

A strong case can be made for assignment of top priority to more thorough use of unmodified static models; and of secondary priority to reconciliation of the primary versus secondary approaches to model development. Modifications designed to redress some or all of the conceptual limiations underlying the static model would be useful, but in many instances operational modifications may be long in coming. There are certain exceptions, however, three of which are summarized below. Each has been empirically implemented and found to be useful in assessing the regional economic impacts of public land use alternatives.

Table 5.--Initial and final gross income effects on Baker County economic sectors resulting from a $397,453 loss in gross revenue to dependent ranchers.

Sector from which purchases are made	Direct coefficient	First round spending impact (loss in $)	Direct and indirect coefficient	Final gross income effect (loss in $)
1. Dependent ranching	.05923	23,451	1.07071	425,557
2. Other ranching	.05826	23,156	.07468	29,682
3. Other agriculture	.01919	7,627	.04962	19,722
4. Food processing	.03560	14,149	.04676	18,585
5. Timber harvesting & hauling	0	0	.00086	342
6. Lumber & wood products processing	0	0	.00245	974
7. Agricultural services	.10982	43,648	.15001	59,622
8. Mining & mineral products processing	0	0	.00738	2,933
9. Construction	0	0	.05525	21,959
10. Transportation	.03095	12,301	.06678	26,542
11. Communications & utilities	.01189	4,726	.04814	19,133
12. Finance, insurance, & real estate	.13046	51,852	.20507	81,506
13. Automotive sales & service	.00030	119	.05437	21,610
14. Professional services	.00787	3,128	.03573	14,201
15. Lodging	0	0	.00188	747
16. Cafes & taverns	0	0	.01015	4,034
17. Wholesale & retail trade	.07954	31,613	.29190	116,017
18. Other wholesale & retail services	0	0	.01494	5,938
19. Households	.20583	81,808	.48006	190,801
20. Bureau of Land Management[1]	0	0	0	0
21. U.S. Forest Service	0	0	0	0
22. Local government	.02448	9,730	.05409	21,498
23. Local agencies of state & federal government	0	0	.00544	2,162
Subtotal - All Local Sectors	.77342	307,398	2.72627	1,083,565
24. Nonlocal households	0	0		
25. Nonlocal government	.02949	11,721		
26. Nonlocal business	.07816	31,065		
Subtotal - All Nonlocal Sectors	.10765	42,786		
27. Inventory depletion	.06519	25,910		
28. Depreciation	.05179	20,584		
TOTAL - ALL SECTORS[2]	.99805	396,678		

[1]Grazing fees paid by permittees are treated as import purchases since these funds are returned directly to the Federal Treasury and do not directly influence the operating budget of the Bureau of Land Management's Baker District.

[2]Does not sum to 1.00000 and $397,453 due to rounding error.

Two address elements of the second basic assumption underlying static models: equilibrium and constant trading patterns. The third modification uses the forward linkages revealed in the sales patterns of existing economic sectors to distribute the output effects of an initial change in primary industry supply; and thereby allows the user to address the supply side influences of public land use changes in a more straightforward manner.

The temporal pattern of exogenous disturbances in product (e.g., feeder cattle and wood product) markets as well as in public land "factor markets," and the temporal response by endogenous local sectors to those disturbances, is a significant question in economic impact analysis--but one which the static input-output model cannot address. To more fully appreciate, understand, and evaluate these temporal relationships Johnson (1979) developed and applied a dynamic intersectoral model using primary data, as summarized

elsewhere by Johnson and Obermiller (1982).[8] The dynamic model was successfully applied to a variety of scenarios involving changes in allowable cut on the Malheur National Forest in northeast Oregon, giving particular useful information on the temporal distribution of secondary income changes attributable to cyclical sales by the local wood products industry to final demand. For all sectors of the local economy, dynamic multipliers were found to be higher in value than comparable static multipliers due to the internalization of the accelerator effect. The implication is that conventional applications of static models underestimate the cumulative regional impact of changes in public land policy and/or other exogenous influences. In essence, static models fail to fully account for the regional income effects of land use decisions affecting levels and rates of investment and disinvestment.

Boyle (1981) and Boyle and Obermiller (1982) developed and implemented a method to relax the assumption of constant trading patterns. Their technique is applicable not only to questions of economic growth, i.e., the appearance of new industry or disappearance of existing industry, but also to issues of technological and hence trading pattern change within existing sectors stemming from public land management or use decisions. Minimal data beyond that required for the construction of the conventional static model are needed. The method is of high operational value for two reasons. First, it prolongs the useful life of existing models. Second, it allows input-output and linear programming models to be merged in an analytic construct consistent with the initially incompatible production and cost function relationships underlying the two algorithms.

While conventional static models are applied to changes in final demand, and operate through systems of backward linkages (purchasing patterns), the same models also describe the forward linkages (selling patterns) extant in the regional economy. Epply (1982) used these forward linkages to distribute the output effects induced by an initial change in primary input supply. The conventional demand pull model, with appropriately adjusted technical coefficients, then was used to estimate the final income effects of changes in forage and timber availablilities on public lands. Further refinement of the technique is underway, and additional documentation soon will be forthcoming. The value of her technique is its direct applicability to issues involving changes in the quantity (or price) of inputs controlled by public land management agencies--in contrast to the awkward and quite often inconsistent procedures utilized when extrapolating changes in final demand sales from corresponding changes in natural resource availabilities.

[8]In addition to standard static model data, the operational dynamic model uses capital-output coefficients, excess capacity measures, depreciation rates, desired capacity levels, and various lag parameters. See Obermiller (1982a).

SUMMARY

All three modifications summarized above relax some, but by no means all, of the conceptual limitations underlying static input-output models. None may be as important, or as relevant to sound natural resource management and policy formulation, as more comprehensive and insightful use of conventional static models. To the extent that public land income distribution concerns may be of increasing importance to society, and thus of increasing interest to resource economists and related professionals, it is at least possible that input-output analysis may advance from a supporting to a leading role in future public land planning, management, and decision-making.

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SMALL REGION INPUT-OUTPUT MODELS:

SOME OBSERVATIONS AND RESERVATIONS

John E. Keith

ABSTRACT: The adoption of non-survey input-output techniques by public land management agencies may cause significant errors in impact estimation. A review of current literature indicates that non-survey techniques can lead to errors if the economic sector of interest is not representative or is highly aggregated. Research into these problems should focus on survey and hybrid I/O tables compared to the non-survey tables.

INTRODUCTION

The use of regionalized input-output (I-O) models for analytical and policy purposes by now is a relatively "old" economic technique [see Jensen and Macdonald (1982) for a bibliography]. Within the past five years it has become an institutionalized process in the major land management agencies, particularly in the Forest Service and Bureau of Land Management (BLM). The regional economic analyses using the Forest Services' IMPLAN system (Alward and Palmer, no date) are based on regionalized I-O tables, and these models are more or less recognized as the appropriate tools for the assessment of the regional impacts of public policy. Some states have readily adopted I-O models in their planning (Washington and Alaska, for example) others have not (Utah) and some have utilized several methods (such as Idaho). As regional I-O analysis becomes more widely used, particularly by individuals who have little or no appreciation for either the limitations of the technique or the criticisms which have been voiced among professional economists, it seems appropriate to review the literature and focus on both problems and research needs associated with the kind of regionalized I-O models to which the agencies are becoming committed.

THE THEORETICAL FOUNDATIONS

An I-O table is a set of deterministic linear homogenous fixed-coefficient production functions which relate a unit of output to input requirements in terms of a monetary numeraire for an assumably homogenous set of firms. Since it is obvious that few firms are homogenous, the stochastic nature of aggregated transactions and/or coefficients is disregarded. The issue has been discussed rather widely in the literature (e.g. Hurwicz, 1955; and Gerking, 1979) but the generation of confidence intervals around I-O results is infrequent. These functions preclude substitution among the various inputs to production. Thus, for a given public policy, such as a reduction in AUM's, the accompanying proportional change in livestock sales will be distributed among the inputs according to the direct purchasing coefficients.

Many analyses relate reductions in the use of public resources to final sales using methods which allow input (forage or stumpage) substitution. These frequently are optimization approaches. The theoretical problem is clear. If input purchases change in sectoral composition, so must the I-O table; yet, recalculation and rebalancing of the tables is seldom done. For example, if public land grazing is replaced by the purchase of feed grains and alfalfa, a significant shift among the sectoral purchases is indicated. In many Western livestock operations, use of other inputs, such as fertilizers, might also be affected. How crucial the differences are with respect to projecting regional economic changes is unknown at present and would depend substantially on the structure of the relevant economy, particularly the agricultural sectors. Cross-sectional studies should be undertaken to examine this problem.

A second related issue also is important. The I-O framework, if used to forecast long-term regional effects of public policy, is likely to be incorrect. The I-O is a static model, and as such represents the economy at a point in time. As Miernyk (1966) has suggested, long-term projections require a dynamic model incorporating adjustments to changing relative prices and/or technology.

Some research has been undertaken to dynamicize I-O models but the current agency practice utilizes the static approach. Miernyk (1970a and 1970b) and Bargur (1969) utilized a capital formation approach in order to examine total output changes as a region grows. These models are theoretically relatively simple in that they consist of an augmented matrix of capital coefficients, but they are quite data intensive. In these models, the definition of the "capacity" to output relationship is a difficult problem. Further, they do not address labor markets, economies of scale, or technological advances which affect the capital-output ratios for an industry (Richardson 1972).

An alternative approach in which local market supply functions are used has been studied by Hudson and Jorgenson (1974 and 1976) and Liew and Liew (1980 and 1981). These approaches estimate coefficient changes from market price projections using the dual of a truncated translog production function. The conditions under which the translog production function has a unique associated dual cost function are somewhat restrictive but the approach does allow for relatively sophisticated

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forecasting of coefficient change based on market behavior.

The extent to which the static models generate errors has not been studied extensively, although Polenske (1970) suggests that dynamic models may not be a significant improvement. It is possible that for some applications the static model is a reasonable one, while other situations require a dynamic approach. A broad-based longitudinal study of I-O forecasts and actual changes would be desireable, as would the development of requirements for a relatively simple dynamization routine. Clearly, the more changes expected in a region, the more imperative is the inclusion of structural change.

A third problem in regional I-O analysis is the introduction of new industries or the failure of an old one, both common phenomena in the Intermountain West. The major consideration, other than the identification of regional purchases information, is the adjustment of coefficients to reflect import substitution (sectoral sales) (Lewis and others 1977; Glover and others 1981; Boyle and Obermiller 1982). Although data intensive additions or deletions are not theoretically difficult, if projections are based on infant industries, such as synfuels, transactions data may be wild guesses at best.

A final problem in the utilization of I-O techniques is the interpretation of the various multipliers generated. These multipliers have attracted considerable attention among the agencies and other users of I-O results. Unfortunately, these multipliers have often been misinterpreted and misused. This misuse is as much a problem of the lack of clear definition by economists as misunderstanding by the lay users. It might be more appropriate for all multipliers to be expressed relative to a given parameter, such as final demand, rather than each different parameter. The development of the Type III multiplier, which includes increases in leakages from household consumption, has been a definite improvement, although its planning use appears confined to professionals. Since there have already been some calls for redefinitions of these multipliers (West and Jensen 1980), a thorough review of their use and taxonomy might be beneficial to practitioners.

REGIONALIZING TABLES

Developing regional models entails several difficulties. First, the appropriate region for which the table is to be constructed must be selected. Any designation, from county to multi-state, is appropriate depending upon the purpose of the analysis. In general, the smaller the region, the less likely it is to be self-sufficient and the more important the role which imported inputs play. Judgment is crucial to this choice. The larger the area the more likely it is that secondary data sources will be plentiful, but the larger will be the data requirements for the I-O table. However, most professional economists attempt to include within the bounds of the region the major trading areas for which impacts may be significant. For grazing policy, local agriculture, feed, and livestock marketing areas are of primary importance. For lumbering, the labor market and lumber mills might establish the appropriate region. The development of a consistent set of agency guidelines for establishing regions appears to be a fruitful area of research. Given the way in which the IMPLAN system is currently used, one Forest Service or BLM district's economic impact analysis may differ from anothers solely because of the regional designation (see, for example, the BLM Shoshone District Draft and Final Shoshone Grazing Environmental Impact Statements and Comments).

Second, regionalization can be accomplished using survey (primary) data collection or various reduction techniques applied to national (or state) coefficients. It is the general consensus that the survey techniques (primary data) provide the "best" regional tables (Jensen and Macdonald 1982). The data are specific to the region, so that anomolies in specific industries' technologies (partitive description) are included. Further, the region's total interdependence (holistic description) is also based on actual conditions. However, surveys are very expensive and time consuming.

There are two alternatives to survey-based tables: strictly non-survey techniques and hybrid techniques. For the non-survey techniques, the coefficients reference tables (usually national) are adjusted based on the ability of the local industries to supply inputs, using location quotients, local requirement to production relationships, employment ratios, or other ratios of local to national output (Richardson 1972 - Chapter 10). The criticisms of non-survey techniques are directed primarily at the accuracy of these tables in representing a local economy.

There are reasons to believe that for some sectors, at least, local industries may differ significantly from national norms with respect to the technology which they employ. These differences may be the result of the rate of adoption of advances in technology, local market conditions in which relative prices lead to alternative combinations of inputs, or the existence of a distinct type of regional industry which is not included separately in the national sectoral definitions. The latter is a case of the aggregation of firms into an industry definition. Aggregation of sectors is also often done at the regional level. These aggregations may lead to distortions in the coefficients of the regional table. Whether or not these distortions result in significantly differing projections is not clear.

Doeksen and Little (1968) and Hewings (1971) have shown that aggregation does not bias results from disaggregated models as long as the aggregation does not include the sectors in which final demands change. Katz and Burfond (1981) conclude, however, that aggregation of the industries whose effects are being analyzed does lead to different multipliers than disaggregated analysis would generate. Regional economists, in general, are reluctant to endorse aggregations of those sectors for which changes in final demands are postulated. It should be noted that "hybrid" tables, constructed by

using available secondary data, primary data where appropriate and feasible, and national coefficients to "fill in" data gaps, have been recommended by some researchers as the only acceptable alternative to survey tables (Jensen and Macdonald 1982). To date, there have been few studies comparing the survey, non-survey, and hybrid techniques with respect to their results.

Boster and Martin (1972), using a survey-based Colorado River Basin Study (Udis 1967) and a non-survey produced regional table from the State of Arizona I-O table, applied non-parametric statistical analysis to examine differences in coefficients and multipliers. Their conclusion was that, for holistic results, little evidence of significant differences existed, although for the coefficients some significant differences were in evidence. On the other hand, there are several studies (Burford and Katz, 1981; Drake 1976; and Stevens and Trainer, 1976) which disagree as to the effect of coefficient variation on holistic projections and multipliers. Rigorous studies of the effects of coefficient variations due to survey and non-survey techniques, along with their effects on the analytical results, are definitely needed, particularly in light of agency adoption of the non-survey techniques for policy analysis. If the agencies are utilizing absolute, rather than relative, output from the models, as would be the case for a benefit-cost analysis which included secondary economic effects, then some idea of the accuracy of the I-O models and results is crucial.

Interestingly enough, there have been no criteria developed on which to judge which tables are "better". Most studies have assumed that survey data yields the most accurate tables, but the uncertainty and averaging associated with survey data may cause that assumption to be incorrect. National I-O tables involve the same assumptions. Those SIC sectors which are less detailed, such as the agricultural sectors, may involve significant variability in production techniques. It appears that longitudinal studies of actual impacts compared to the projected impacts could yield some criteria on which to judge these I-O processes.

APPLICATION OF I-O TO GRAZING

Given that the non-survey approach appears to be the dominate regionalization technique in the agencies, an examination of its application to grazing policy impacts is of interest. Insofar as range livestock is concerned, the national sector which is used is an aggregate of all meat livestock production in the U.S. The purchases of inputs by Western ranchers are likely different from those of beef or lamb production in the Midwest or South. In fact, the latter two regions make up a sufficiently large portion of the livestock industry that it is probable that the national or average livestock sector is significantly different from that of the Western region.

While the precise regions are different, some interesting comparisons can be made among several regional I-O tables for the Intermountain region.

Table 1 presents a comparison of some of the livestock sector coefficients (greater than .005) for Millard County, Utah, (produced by the IMPLAN model), White Pine and Lincoln Counties, Nevada, (produced by the Forest Service Region 4 model), Southeastern, Utah, (produced from a location-quotient reduction of the State of Utah I-O table [Bradley and Fjelsted 1975]), and a range livestock sector for the Upper Main Stem of the Colorado River Basin (produced with a survey approach by Udis 1967). The first two non-survey tables are based on a 1972 national table; the third, on a 1965 Utah table updated to 1972 using secondary data sources for in-state sales by sector. The data for the Udis model was collected in the early 1960's.

Table 1.--Selected technical column coefficients for the livestock sector

	Millard County	White Pine and Lincoln County	Southeast Utah	Upper Main Stem
Livestock	.29	.28	.186	[1] .166
All other Agriculture (including Food and Feed Grains)	.283	.199	.124	.080
Wholesale and Retail	.032	.005	.041	.031
Fire[2]	.019	.004	.008	.044
Transportation	.007	.003	.017	.021

[1] Includes a weighted average of range and feeder livestock effects.

[2] Financial, insurance, and real estate.

From a partitive aspect there are wide differences in the tables for each area, particularly in the more significant livestock input sectors. These differences could be explained on the basis of dissimilar regional economies; yet each of the regions is an agriculturally based, particularly livestock-oriented, area with a limited diversity. If anything, the Upper Main Stem area is more diverse than the other regions. Further, note that many of the coefficients presented by Obermiller (1982) for non-dependent operators are quite different than those for dependent operations in a single region (Baker County, Oregon). Given that the IMPLAN uses a national aggregate for the livestock industry, the problem is clear.

Table 2 lists the livestock sector multipliers which are generated from each of the four tables. The holistic results appear to be reasonably consistent for the three non-survey models, although the results from the regionalized State of Utah tables are somewhat lower than those from the national tables. However the survey-based model

Table 2.--Multipliers for the livestock sector

	Output		Income	
	Type I	Type II	Type I	Type II
Millard County	2.27	2.59	3.7	4.83
White Pine and Lincoln County	1.95	2.40	3.3	4.3
Southeast Utah	1.82	2.27	2.80	4.01
Upper Main Stem	[1]1.30			

[1]Range livestock only; feeder livestock multiplier was 2.3, most of which was based on purchase of local range livestock as inputs.

generates a considerably lower Type I multiplier for the range livestock sector. The gross output multiplier using a weighted average of the range and feeder livestock sectors is 1.46.

These comparisons suggest two conclusions. First, the partitive coefficients may vary widely among alternative approaches and data bases. Second, the holistic results (multipliers) may be reasonably consistent for approaches using similar data bases, but may be quite different for survey and non-survey techniques.

A possible explanation for the differences in livestock multipliers lies in the relationship between the purchases of feed and feed grains in other regions (Midwest and South) and the integration of feed production into the livestock operations in the Intermountain West. The aggregation which is reasonable at the national level may not be representative at the local level. The IMPLAN results for grazing policy are likely biased, since the sector of interest is an aggregate one. Range livestock operations use many of their purchased inputs to produce joint products (feeds and livestock), and feed crops are "marketed" through the livestock. These kinds of vertically integrated production processes would be captured by survey approaches.

At the very least, then, an examination of the input use and transactions of Western industries which are affected by public land policy should be undertaken. If these industries appear to significantly differ from the national industries, a hybrid model should be developed by the agencies. Further, survey-based, non-survey-based, and hybrid tables should be developed for selected regions in order to assess the reliability of each. Nationwide adoption of the IMPLAN system in its present form should receive a critical evaluation.

OTHER IMPACT ASSESSMENT APPROACHES

As previously mentioned, several states have opted for alternatives to I-O analysis. Some have used regional econometric models and others have used more or less sophisticated export-base approaches [such as Utah's UPED model (Bigler and others 1972)]. It would seem reasonable to assess the accuracy and efficacy of these models as opposed to I-O analysis, particularly when a specific analytical approach is adopted nationally as is the IMPLAN system. Longitudinal studies of projection accuracies relative to cost of development should be examined. Given that the closer coordination of state and federal policy continues, some reconciliation of these approaches should be attempted.

SUMMARY AND CONCLUSIONS

Several areas of theoretical and empirical research needs have been identified in the literature. Among the more crucial are the assessment of the value and accuracy of survey and non-survey techniques in table preparation, impact projections and policy analysis, the dynamicization of I-O tables in rapidly changing regions, comparisons of I-O and alternative techniques for policy use particularly with respect to accuracy of projections, and the development of consistent criteria for selecting regions to be modeled. In particular, the Western range livestock and other public resource dependent sectors should be examined for differences in technical coefficients among IMPLAN, survey, and hybrid models to more accurately reflect the affects of policy.

The use of IMPLAN and other non-survey I-O tables for both impact analysis and policy planning may have had some negative effects. It is not clear that regional economic analysis has had much impact on policy decisions with respect to grazing for three reasons. First, it is seldom that proposed actions have a significant effect (5 percent change) on total regional output or value added. Second, land managers may not necessarily regard economic impacts as important relative to the biological integrity of resource areas. Third, economic impacts at the regional level are not specified as an economic decision criteria in Forest Service and BLM policy (only national net benefits, i.e., economic efficiency is to be a decision variable). Results from I-O analysis appear to have exacerbated antagonisms among ranchers, managers, and other groups partially because the results reflect potential income transfers more clearly than efficiency gains.

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INTERFACING PHYSICAL DATA AND ECONOMICS

Warren P. Clary

ABSTRACT: Inaccurate physical data or data assumptions can completely invalidate the best economic analysis. Existing field data are used to illustrate the potential impact of data variations on simple economic analyses. Lack of a uniform range forage unit and the need for multi-product management on rangelands also are discussed.

INTRODUCTION

This discussion is presented from the viewpoint of a non-economist who has had periodic associations with economists. Such associations have made me aware of some of the potential uses of physical data in at least the simpler forms of economic analysis. The accuracy of the data utilized can greatly effect the analysis outcome--simply arriving at the correct economic assumption does not guarantee the correct economic answer. Likewise, assuming a consistent dominant use on a particular piece of land does not guarantee the most efficient land use.

Four information areas will be covered which appear to be often consciously or unconsciously overlooked by those dealing with economic analyses of rangeland activities. These are (1) statistical sampling errors in the physical data, (2) differences in site productivity, (3) lack of a uniform product, and (4) apparent lack of consideration for maximizing land output considering several products or uses.

STATISTICAL SAMPLING ERRORS

The possibility of major sampling errors in the physical data is often ignored or disregarded based on the feeling that "it's the best we have." Perhaps, however, we should examine the possibility that the best sometimes is not good enough, and that bad information can be more harmful than no information at all.

What magnitude of error is likely to occur in field data? The kind of sampling effort which can be made greatly affects the answer (Baker 1957, Ostle 1957). Several typical examples illustrate the possibilities. The minimum number of site analysis transects per chaining project on National Forests is normally one (1) if conditions are reasonably uniform. This minimum of one is not regularly exceeded because of personnel limitations. What magnitude of error can we expect using a single sample site per chaining project?

Suppose an unchained Utah pinyon-juniper stand had a true population mean of 60 lb of herbaceous plants per acre, with a standard deviation of 52 lb/acre. Although these true population values would never be known in practice, using this hypothetical case can illustrate the sampling problem. The mean and standard deviation are not unreasonable because they were actually obtained as sample estimates of some unknown population values. If the true unknown mean were 60 lb/acre, we would find that 20 percent of the time our single transect would yield a value either near zero or greater than 127 lb/acre. Further, suppose that an adjacent chained area had a herbage production mean of 694 lb/acre with a standard deviation of 234 lb/acre. Again, these values would not be known to an investigator, but nevertheless would control the results of our sampling. If we sampled with a single transect, we would find that 20 percent of the time the sample value would be either below 394 lb/acre or above 994 lb/acre. This would be the case even though the true population mean was 694 lb/acre.

If we were to compare the forage yields from these adjacent chained and unchained areas to assess the economic benefits from chaining, what effect would the sample variation have on a simple B/C analysis of the chaining project? A considerable difference in possible results appears when a comparison is made of the gain in forage (assume for simplicity, all herbaceous growth is forage) versus the cost to obtain the gain. If the lowest sample value before chaining and the highest sample value after chaining appear in our comparison then the apparent gain in forage is 994 lb/acre. If the opposite extremes occur together then the estimate of gain due to chaining would be only 267 lb/acre.

Now, let's say a current typical cost of double-chaining with seeding is \$30 per acre, the present net worth of an increase of one animal unit month (AUM = amount of forage required per month by a 1,000 lb ruminant animal) is \$60, utilization rate is 50 percent, and forage required per AUM is 720 lb. The B/C ratio could vary from 1.4 to about 0.4. Thus, the potential interpretations could range from one of a very successful project to one of near failure simply because of variation among small samples.

The benefits of larger sample sizes can be seen in figure 1. The value limits needed to include 80 percent of the sample means come closer to the true population mean (which is normally unknown)

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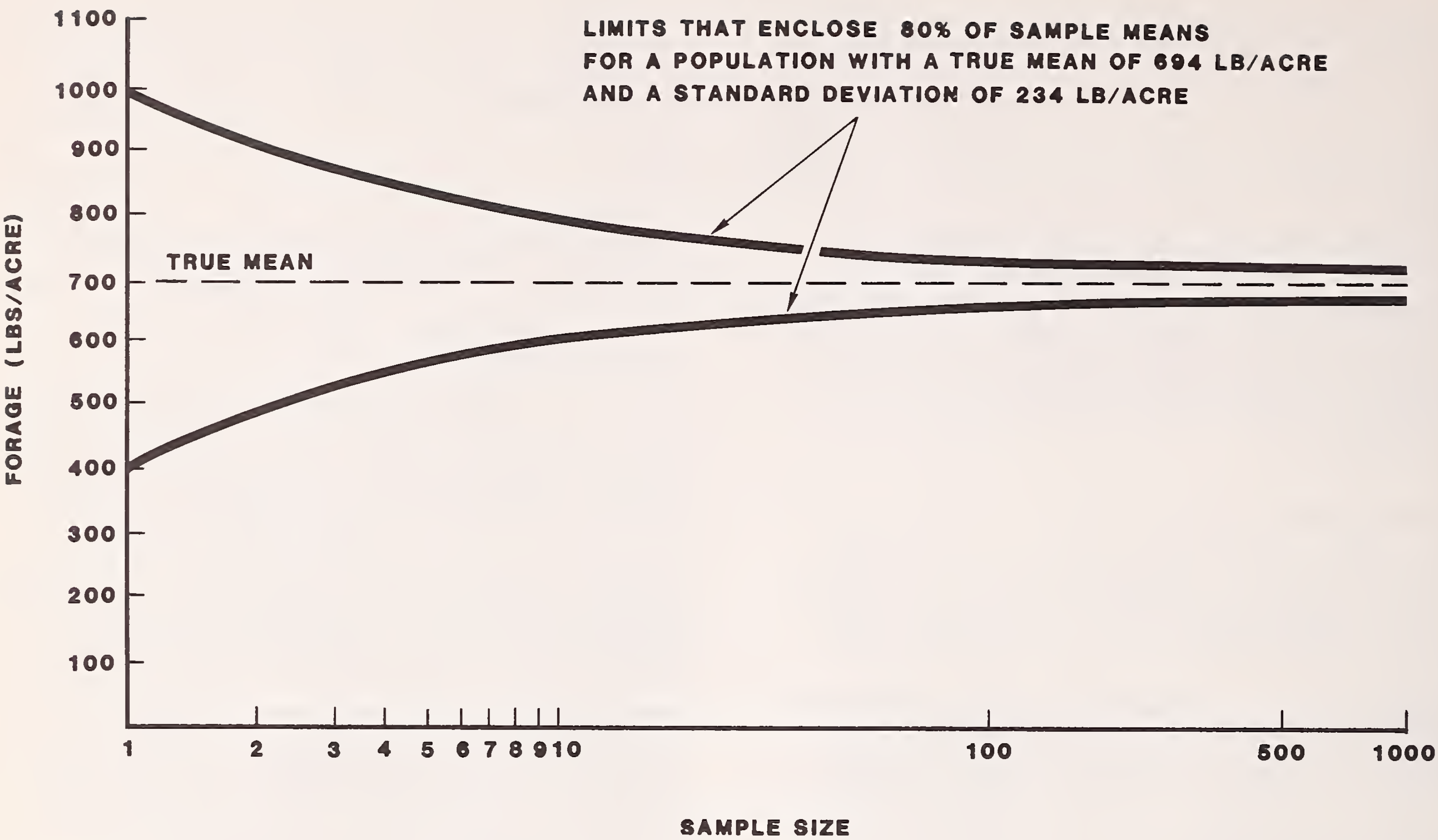

Figure 1.--Relationship between sample size and variation of sample means.

as the size of sample contributing to the sample mean increases. The benefits of increasing the sample size noticeably decrease the sample variability. As the sample size becomes substantial, very large additional sampling efforts are required to produce further meaningful increases in sampling precision. For example, if the sample size is increased from 1 to 10, the variability among sample estimates is greatly reduced, giving B/C ratio estimates of 1.0 to 0.7. These estimates are sufficiently stable to provide usable information for those needing it.

DIFFERENCES IN SITE PRODUCTIVITY

Available data suggest that the variance in herbage production among years is likely to be of the same magnitude as that among sample sites (Clary 1971). Thus, analyses based on only 1 year of posttreatment data are subject to the same potential problems as are within year data based on only one sample site.

An obvious practical approach to solving the problem is to accumulate information from a number of projects and develop average values to be generally applied. This probably is sufficient to provide broad guidelines. When applying these general figures to specific situations, however, we can again greatly miss the mark. Another example is taken from Arizona where annual production of grasses varied from 419 to 2,617 lb/acre among different pinyon-juniper sites (study described in Clary and Jameson 1981). Any general figure applied to these individual sites would have little meaning. Because all of the Arizona sites, but two, could probably be treated at a similar cost, the calculated B/C ratios among the remaining sites would vary from 3.4 on an extremely responsive site to only 0.2 on an unproductive site. Thus, generalized figures applied to a variety of sites can and almost certainly will result in misleading information.

LACK OF A UNIFORM PRODUCT

As I understand it, most approaches used to determine product values rest on the concept that all units of a product have equal value and should receive an equal market price under full competitive market conditions. The FRES or Forest-Range Environmental Study conducted in the early 1970's and the initial analyses conducted by the Forest Service during the mid- and late 1970's in response to the Forest and Rangeland Renewable Resources Planning Act (RPA), both assumed that AUM's were equivalent nationwide. This allowed a rather straightforward linear programming solution to determine where in the nation increases in AUM's of grazing could be developed at the least cost. However, the question of equality of AUM's does not seem to have been formally addressed. I doubt if anyone would be surprised at the suggestion that forage on the same site has different levels of value to the grazing animal at different times of the year or that at the same time of year different locations may have forages of different values (Plath 1957).

One example of this comes from a comparison of beef gain potentials on cool semiarid pine forest ranges in north-central Arizona and subtropical pine forest ranges in central Louisiana (Clary and Grelen 1978). These two areas have several similarities. Both are typified by open pine forest stands with grassy understories, and both historically have been important cattle grazing areas. The forage production after removal of trees is about double in Louisiana compared to Arizona. Thus, analyses based on estimated AUM's of grazing would show about double the value per acre in Louisiana compared to Arizona. However, reduced protein content and digestibility of the native southern forages result in the actual beef gains per acre being roughly equivalent for the two areas. Thus, presumably, the potential grazing rental value of the two areas would be approximately equivalent per acre--not differing by a factor of two based on AUM's of forage.

Interactions of forage quality and season also often occur. An AUM of poor quality forage in a season of forage shortage may be worth more than an AUM of high quality forage in a season of surplus. Many other examples exist which suggest that not all AUM's are created equal and analyses assuming that they are miss the mark.

CONSIDERATION FOR MAXIMIZING LAND OUTPUT

The last point I would like to make is that there seems to be an excess of land use stereotyping. An area designated as "forestland" usually receives significant manipulation only to achieve certain levels of wood production, while "rangeland" normally receives investments designed only to improve range animal production. It seems that economists have the approaches and tools to help achieve a more efficient use of the land which could come much closer to maximizing the combined product and use values. Martin (1981) states that agricultural economists interested in rangelands would like to examine economic options for multiple product areas including the public ranges, but there is little information on the marginal rates of substitution between multiple products that may be produced on the range in addition to domestic livestock. If this is the case, perhaps range economists should play a more active role in determining what physical data should be collected (Brown 1959, Vaux 1959).

A production possibilities frontier from the Wild Bill Range in Arizona illustrates that some data are available and can be used to guide management decisions (fig. 2). A generalized curve for merchantable wood growth under uneven-aged management is illustrated here. The exact shape will vary with differences in tree size class distribution. It is assumed that a sufficiently large area is represented so that selective harvest timber sales result in removal of the equivalent of the average annual growth for the entire area each year. The forage is harvested annually across the area. Different points on the frontier are achieved by managing the timber stand at different density levels (Clary and others 1975). As the timber stand is thinned, less merchantable tree growth per acre occurs; but livestock-carrying capacity increases. Transformations of yield from one product to another is not linear, but curvilinear. The question of "what is the best combination of these two products" can be answered by applying product values.

The rental value of livestock grazing seems to be reasonably uniform among areas, while the wood values seem to be quite different depending upon the year and on wood use. In 1972 the product values were approximately $100/MBF of ponderosa pine stumpage and $6/AUM of grazing (Clary and others 1975). The corresponding unit values were 50 cents per cubic foot of timber and 12 cents per yearling-day of grazing. Matching the isorevenue line to the product possibility frontier, and considering only those stands whose stem diameters are sufficient to be marketed for dimension lumber, we find that the combined product value is maximized at high tree densities where little grazing is possible (fig. 3).

The situation has changed greatly 10 years later. The rental value of grazing has maintained or even increased its value while timber stumpage values for dimension lumber have dropped considerably. Current prices for three wood products are approximately $10 per 1,000 board feet of dimension lumber, 50 cents per cord of pulpwood, and $7.50 per cord of fuelwood. Using these prices to construct isorevenue lines, we find that the markets available to given timber stands greatly affect the stand density at which combined grazing and timber values would be maximized. Figures 4, 5, and 6 illustrate the different results which occur depending upon the products marketed from a timber stand. If the wood is marketed for use as dimension lumber the combined value of grazing and timber is maximized at a rather low tree density where moderately high amounts of grazing and intermediate amounts of wood are produced. However, if the only market for the wood is pulp, the wood values are so low the highest combined product value is obtained by removing the timber stand and producing maximum grazing capacity. Currently, the highest wood values appear to lie in the fuelwood market. If this timber could be sold as fuelwood its higher value results in product values being maximized at intermediate timber stand densities with intermediate grazing capacities and moderately high wood growth. A dynamic programming approach (Riitters, and others 1982) used on even-aged timber management also illustrates how combined product values can maximize benefits.

The purpose here is not to belabor the wood market, but to illustrate that economic tools can and probably should be used to help guide management decisions if land management policy includes the need to maximize benefits. The same can be said for nontimber types, primarily thought of as grazing areas. In the mountain brush type, accessible from population centers, the fuelwood values of oak, maple, and similar species appear to equal or exceed grazing values even when compared on an annual production basis[1].

[1]Tiedemann, A. R.; Clary, W. P.; Wagstaff, F.; Harper, K.T. Developing management strategies for the Gambel oak habitat of the western United States. Presentation at the Annual Meeting, Utah Section, Society for Range Management, January 1981.

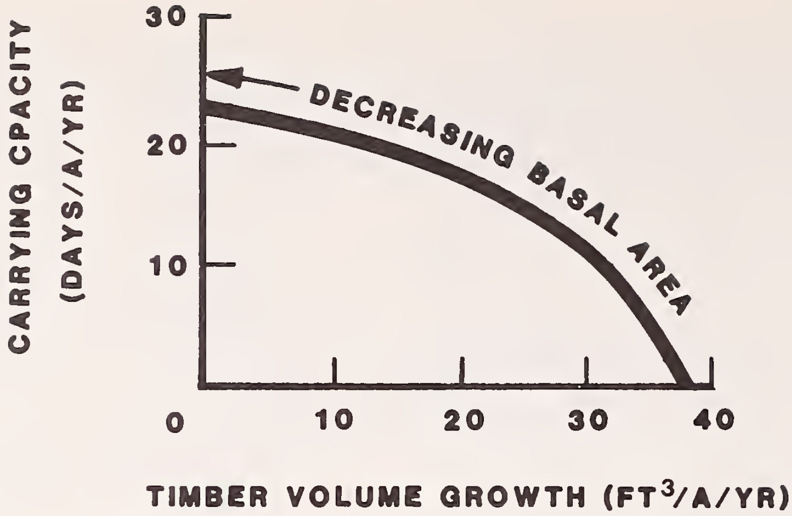

Figure 2.--Production possibilities frontier for livestock grazing and wood growth.

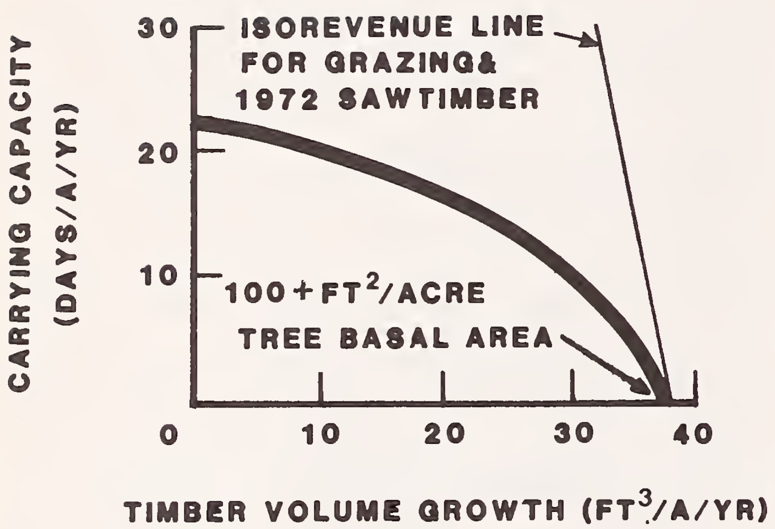

Figure 3.--Optimum thinning intensity when considering grazing and 1972 sawtimber prices.

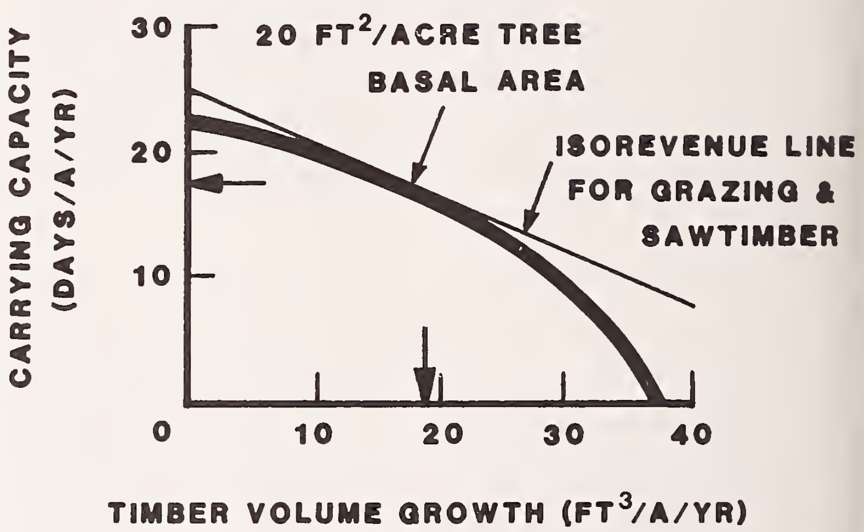

Figure 4.--Optimum thinning intensity when considering grazing and current sawtimber prices.

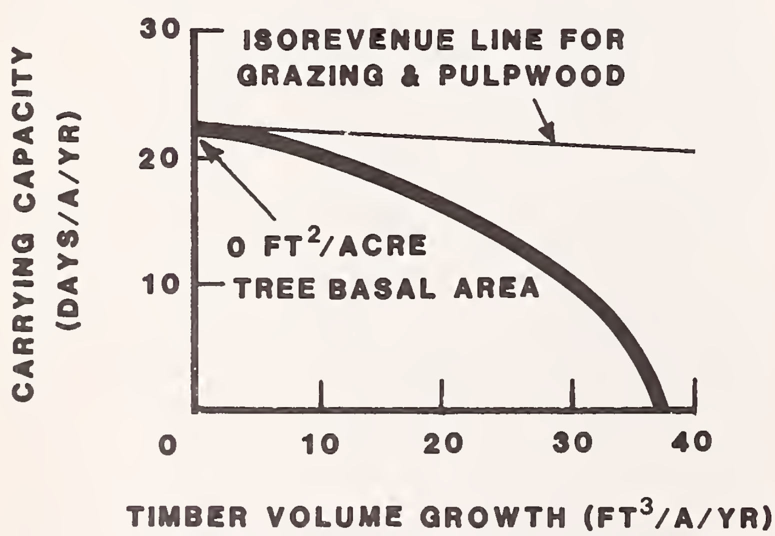

Figure 5.--Optimum thinning intensity when considering grazing and current pulpwood prices.

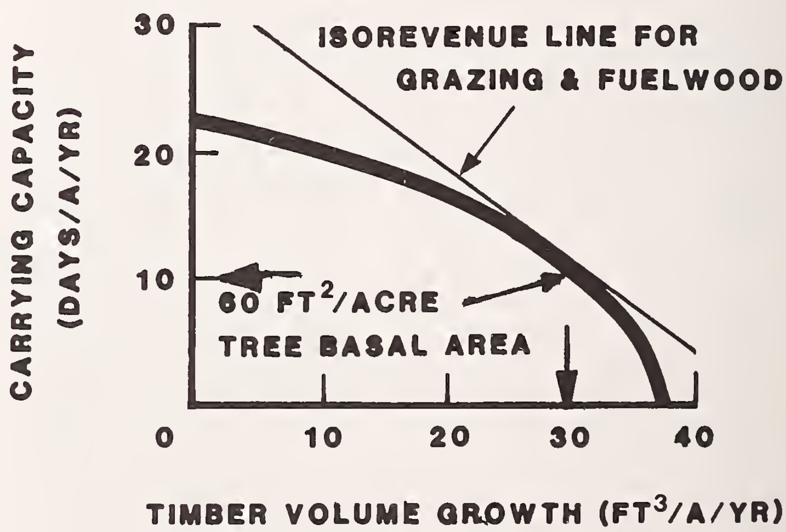

Figure 6.--Optimum thinning intensity when considering grazing and current fuelwood prices.

Liquidation of the current standing crop of Gambel oak fuelwood could result in substantial income per acre (Data on file, Shrub Sciences Laboratory, Provo, Utah). Yet, until quite recently, little thought was given to management for fuelwood production, partly due to unawareness of fuelwood values and demand, and partly due to concern about excessive sprouting of Gambel oak. Although fuelwood sales could perhaps be made without any detriment to continued grazing use of the sites, there is little documentation of the tradeoffs of increased herbaceous forage production resulting from removal of the overstory versus the potential of decreased livestock accessibility due to prolific sprout production. Additional knowledge is required for optimum management.

Many sites, however, are so thoroughly occupied by Gambel oak that there is very little long-term grazing potential. On these sites the only meaningful grazing value would occur during the early years following a fuelwood harvest. In these situations wood harvests could result in increased grazing values in addition to the potentially high fuelwood sale values. Likewise, the fuel producing potential of pinyon-juniper stands should perhaps be considered in their management. Management of an area for a single use often results in total benefits that fall far short of the potential. Use of economic tools in management decisions can improve our ability to achieve maximum benefits from the land.

CONCLUSIONS

1. Physical sampling errors and differences in site productivity can make economic analyses meaningless. If management or policy decisions are to be based on economic analysis, be sure the physical data are reliable--or don't use them.

2. Different AUM's have different values for animal production. Range economics will have more meaning if the value differences among AUM's are recognized.

3. Greater consideration should be given to maximizing combined product values. There should be increased efforts to deal with more than one use of a piece of land. Rangeland economics is more than ranch budgets.

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ECONOMETRIC ESTIMATION OF RANGE FORAGE DEMAND

Thomas M. Quigley and R. G. Taylor

ABSTRACT: Econometric analysis provides an alternative approach to the estimation of demand for forage. Econometric application requires the specification of structural forms for the production relationships, data aggregation and separation decisions, and the possible estimation of multiproduct production functions. The relationships which result may involve relatively few variables, compared to optimization studies, and data collection techniques may be simplified.

INTRODUCTION

Federal legislation and regulation have placed increased emphasis on the determination of demand and supply relationships for those goods and services being produced from Federal land. Specifically, the Forest and Rangeland Renewable Resources Planning Act of 1974 and the National Forest Management Act of 1976 require valuation of goods and services. Although the valuation of goods and services does not necessarily require the establishment of a price quantity relationship, Federal regulations state this as a goal (Federal Register 1979, 219.5e2, p. 53986). Federal forage is a factor (input) used principally in the production of wildlife and domestic livestock, as well as indirectly in other ecosystem outputs (for example, water, timber, and recreation). Although the theory of production includes all outputs, we will deal exclusively with domestic livestock.

Federal ownership and resulting current fee formulation circumvent competitive market pricing of forage. In the absence of markets, an indirect valuation procedure becomes necessary. A brief review of previous approaches will be presented, not to be all-inclusive but rather to outline an avenue for econometric estimation of demand.

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Definitions

Several distinctions are necessary to alleviate confusion and misunderstanding that might be associated with this topic. Demand in an economic sense represents the relationship between the price of a good and the quantity which consumers will purchase at the market place. Because range forage represents a factor of production (one that does not provide satisfaction in and of itself, but rather through its use in further production) its demand can be estimated through the production relationship it has with other products. In this sense, forage demand is a derived demand. Further, forage valuation represents a point estimate of demand, where any value (price) is determined for a specific quantity and time.
That field of economics which combines statistical estimation and inference with economic theory is termed econometrics. Econometrics deals primarily with stochastic problems, as opposed to deterministic techniques such as linear programing. Econometric studies of input demand have taken two main approaches. The first method relates through regression techniques, the price of the factor, and its quantity as observed in the factor market place (other variables are generally included such as the prices of substitute and complementary goods). The second method is to estimate the derived demand relationship through estimation of the production process involving the factor.

PREVIOUS WORK

The indirect approaches that have been applied to the ranching industry to determine value and/or demand of forage include: (1) comparable private lease rates, (2) alternative forage sources, (3) capitalized permit values, and (4) mathematical programing techniques. Each approach will be briefly discussed.

Comparable Private Lease Rates

The concept of a comparable private lease rate employs the idea that there exists a competitive market where forage comparable to that available on Federal land is exchanged. The lease rates observed within these markets would then represent the marginal value of the forage on private as well as comparable public land. The 1967 study by the U.S.

Departments of Interior and Agriculture used this approach to arrive at "fair market value" (Bergland and Andrus 1977). This value was estimated by reducing the comparable private lease rate, determined through survey techniques, by the unique non-fee costs associated with Federal grazing.

The obvious criticisms leveled at the comparison method are bias and error in technique such as difficulty in considering seasonal and quality variations in forage or variation in services or costs associated with the lease. The most damaging criticism of the comparison approach is not the fallibility of the technique itself but rather what the measurement represents in the absence of error. The cross-price elasticity of forage demand between private leased grazing and Federal lands has yet to be determined. When a massive amount of Federal grazing is set at a fixed price, the cross-price effect on a modicum amount of comparable private leases is unknown. Any degree of complementarity would violate the assumption of complete substitutes necessary to make a comparison valid.

Alternative Forage Sources

The approach of alternative forage sources examines the alternatives available to ranchers in acquiring forage from other sources. Hay, supplements, and pasture might be examined to determine the costs associated with acquiring this forage. Through a series of quantitative and qualitative indices the price for the alternative forage is converted into a price which is supposed to represent the value of Federal forage. This technique was applied in the 1980 RPA range valuation process and is commonly referred to as the Nebraska hay formula (United States Department of Agriculture 1980). Inconsistent results might be anticipated from this approach due to the qualitative nature in which the conversion occurs and the difficulty associated with assigning representative values to large areas of diverse vegetative composition. Again the question arises as to whether hay is a substitute or a complement in range livestock production.

Capitalized Permit Values

The theory underlying the capitalized permit value approach has been stated by Roberts (1963) and others (Gardner 1962; Roberts and Topham 1965; Roberts 1967; Martin and Jefferies 1966). The difference between grazing value and the fee plus non-fee costs are capitalized into the permit value. In addition to the inherent difficulty in estimating the value of the permit, recent questions relating to the uncertainty of permit tenure have introduced variation (Fowler and Gray 1980). Winter and Whittaker (1981) also reported that the exchange prices in land sales were not affected by permit holdings. Another criticism is that permit values like ranchlands have been subjected to speculation increases or that owning the permit has a consumptive value (that is, an intrinsic value beyond its contribution toward further production).

Mathematical Programing Approach

Optimization studies including linear programing and budget analysis constitute the majority of the technqiues applied. The current work by Gee (1981) in cooperation with the USDA Forest Service and USDI Bureau of Land Management is an example of this technique applied to the valuation of range forage. Bartlett and others (1981) utilized this approach to determine a price quantity relationship for the demand for Federal forage in Colorado. This study examined the net changes in income from beef production attributable to varying levels of Federal forage input.

Within this classification, we will include national and regional deterministic models which include livestock and/or grazing demand. These are generally optimization, such as the National Interregional Agricultural Projection (NIRAP) System (developed by the USDA Economic Research Service), or simulation (Klein and Sonntag 1982) models designed specifically for applications in planning and policy analysis. These approaches rely heavily on the alternative decision variables the analyst incorporates in the model. The price elasticities and substitution rates, important in policy analysis, associated with these models are fixed over portions of the production surface.

Substitution of inputs within a linear programing formulation occurs implicitly in alternative production activities, rather than explicitly among specific inputs. Demand estimation from linear programs relies on the analysts' formulation of alternative production activities (deterministic) rather than estimates of the degree of substitution (stochastic) which occurs within the production process.

Econometric Approach

Godfrey (1981) recently outlined research needs to estimate the demand and supply of forage. His descriptions were limited to direct econometric estimation of a demand equation using prices and the estimation of derived demand using multiple inputs and beef as a single output. We will examine the general model for multiple outputs and multiple inputs as well as discuss alternative econometric approaches which

might prove useful in forage demand estimation.

ECONOMIC THEORY OF MULTIPLE-OUTPUT PRODUCTION

Production function work prior to the 1970s, typified by Heady and Dillon's text (1961), was characterized by "engineering" type relationships. Here the design emphasized technical relationships among inputs and corresponding outputs and the determination of optimum input combinations. This contrasts with later approaches, which are designed more to relate the actual behavior of production units with the associated prices. The ultimate use of these later models is to predict how demand for inputs and supply of outputs will vary as prices change, rather than to recommend an optimal input and output mix to the producers.

The use of multiple-output functions is a necessary step for all but the simplest formulation of an estimation procedure for deriving the demand for forage. A simple cow-calf ranch operation could be modelled as a single output even though the ranch sells calves, cull cows and cull bulls. The culls can be assumed to be sold in fixed proportions to calves, thus conforming to a single output formulation. When the model incorporates cow-calf-yearling operations, the proportion of yearlings retained or purchased varies. The restriction for fixed proportions is violated and a multiple-output formulation is necessary.

Theoretical work into multiple-output production functions was pioneered by Klein (1947) in his study of the U.S. railroads. Mundlak (1963) introduced the transcendental multiple-output production function which corrected some theoretical problems associated with Klein's formulation. Work by Powell and Gruen (1968) and Mundlak and Razin (1969) has generalized the multiple-output production function to avoid possible shortcomings in formulation.

Within the ranching industry, those economic units which combine several inputs to produce several outputs constitute a ranch or firm. The general assumption is made that these firms operate so as to maximize profit. The source of revenue, outputs, as well as the source of costs, inputs, can be referred to as variables from an econometric viewpoint. The distinction between endogenous and exogenous variables is made through the interpretation of which variables are determined within the econometric model. Endogenous variables are determined within the model.

The long run situation could then be described as having all inputs and outputs endogenous. The introduction of exogenous variables render the problem to a short run situation. The prices (input and output) are placed on the firm through the market system, thus they are usually taken as exogenous. The internal technical constraint faced by the firm is provided through the multiple-output production function.

The production function faced by the firm describes the input-output combinations which are technically efficient. The technically efficient multiple-output production function can be represented by the implicit function:

$$F(Y,X) = 0 \qquad (1)$$

where Y is a vector of outputs and X is a vector of inputs. This relationship specifies those efficient combinations of inputs and outputs that are technically feasible.

Thus, given the level of all inputs and all outputs except any one, say Y_i, relationship (1) specifies the maximum amount of Y_i which can be produced. Alternatively stated, given the level of all outputs and all inputs except any one, say X_j, relationship (1) specifies the minimum amount of X_j required.

Important work into the relationship and use of profit, cost, and revenue functions in multiple-output production processes has been accomplished by Shephard (1970), McFadden (1970), Lau (1972), and Jorgenson and Lau (1974). A summary of this work together with the empirical application of several functional forms to the U.S. railroad industry is given in Hasenkamp (1976). To date, the majority of the multiple-output production studies utilizing econometrics have examined national production questions where inputs are highly aggregated.

To provide a production function which satisfies the theoretical conditions specified by multiple-output production theory, certain restrictions must be placed on the function F (Lau 1972). These include: (1) F must be continuous, twice differentiable, convex, and closed in Y and X; (2) F must be strictly decreasing in X and increasing in Y; and (3) Y must be finite for all finite X; and X must be finite for all finite Y.

Given a production function F which satisfies the above conditions, the least cost combination of inputs (X) required to produce a stated vector of outputs (Y^*) can be determined through satisfying the cost minimization problem:

$$\text{minimize} \quad \sum q_i^* X_i \,;$$
$$\text{subject to} \quad F(Y^*,X) = 0$$

where Y^* is a given output vector and q_i^* represents the price of input X_i. This assumes that all outputs are exogenous and that the input prices are known.

The dual allows a restatement of the cost formulation above as a revenue problem. As a revenue problem, the formulation becomes the determination of the revenue maximizing combination of outputs (Y) which can be produced from a given input vector (X^*):

$$\text{maximize} \qquad \Sigma p_j^* \ Y_j \ ;$$

$$\text{subject} \qquad F(Y,X^*) = 0.$$

When the X^* input vector is set equal to the solution of the cost problem, the resultant output vector Y from the revenue problem is the same as specified in the cost problem. This relationship is known as duality and provides a basis for much of the multiple-output econometric applications in production theory.

By combining the concepts of cost minimization with revenue maximization one arrives at the profit function. The profit function represents the solution to the problem of maximizing the difference between revenue and costs subject to the production function. Algebraically the maximization problem can be represented by:

$$B = p'Y - q'X - L(F(Y,X)) \qquad (2)$$

where p' is a row vector of output prices, q' is a row vector of input prices, and L is the Lagrangian multiplier associated with the production function constraint on profit. The maximized value of B is the profit function $B^*(p,q)$ and is given by:

$$B^*(p,q) = \max B = p'Y^* - q'X^*$$

where the * signifies the optimized values.

The derivation of the derived demand functions for the inputs comes from the familiar Shephard's Lemma (Baumol 1977). Simply stated it is that the first partial derivatives of the profit function with respect to the input price vector yield the negative of the vector of input demand functions. It further provides that the vector of output supply functions is derived from taking the first partial derivatives of the profit function with respect to the vector of output prices. Thus,

$$\partial B/\partial p = Y^*(p,q) \quad \text{and} \qquad (4)$$

$$\partial B/\partial q = X^*(p,q) \qquad (5)$$

represent the output supply and input demand functions, respectively. The properties of the profit function and the basic theorems (and proofs) regarding them are given in Lau (1972).

ECONOMETRIC APPROACHES TO FORAGE DEMAND

Now that we have outlined multiple-output production theory we can examine econometric research approaches to forage demand. These approaches can be classified into different methods; (1) direct estimation of production functions, (2) dual approach to derived demand, (3) pseudo data approach, and (4) econometric market models. Before we detail each of these approaches let us review some problems common to all approaches.

Problems Common to All Estimation Procedures

Each procedure necessarily involves decisions concerning the level at which the estimated demand will apply. These levels include firm, regional, or national. The collection of data and the applicable analysis procedure will depend on the level selected. National models may include more than one market area and, thus, price variation within a year; while firm level models may involve sampling firms which are from different market regions and estimating production relationships irrespective of region.

A related problem is which data series to employ for the estimation. The typical data sets used in econometrics are cross-sectional (one time period), time-series, and pooled. For forage demand, few consistent time-series data sets exist. This causes a particular problem for the dual estimation process which is well suited to time-series data. In fact, to avoid multicollinearity problems within the dual framework, the data must show variation in prices. This can be accomplished through time-series or multi-market data. This represents a major drawback to the estimation of input demand and output supply relationships (the dual approach) using cross-sectional data. The pseudo data approach enables the use of the dual in estimating forage demand by avoiding the multicollinearity problem through the prices selected.

Derived forage demand represents a return to what factor? Does the derived demand represent the return to beef, land appreciation, consumptive value in ranching, or some other item? This is clearer if you consider linear programing. The demand derived as in Bartlett and others (1981) is the return to beef. In formulating the multiple-output problem, the return should reflect changes in the entire production process, not just beef. This could be contrasted with the comparable private lease and capitalized permit value, which represents returns to different factors.

Regardless of the approach one takes toward the determination of Federal forage demand through econometric means, the problem of data aggregation must be addressed. The decision to aggregate should be based on theoretical, practical, and computational considerations. Heady (1961) stated that aggregation introduces bias in the estimated parameters. He suggests that quality differences exist in both inputs and outputs (every acre of land is not equal, every hour of labor is not equal) and that the failure to account for these quality differences results in specification bias. He suggests two working rules to minimize the bias due to aggregation. First, treat perfect complements, that is, resources used in fixed proportions, as a single input. This reduces multicollinearity problems due to correlation between complements. Second, aggregate perfect substitutes into a single category. This would ideally be done using standard units; however, standardizing weights might be necessary, and these are difficult to determine in some cases.

Within the ranching industry, these problems are not trivial. For example, labor is in many forms, from hired youth to highly skilled contractors (for example, shearers), yet is often reported in total hours irrespective of the form. With respect to Federal forage demand, private forage is nearly a perfect substitute which by Heady's rule would warrant aggregation into a single input, while other seasonal forages may be perfect complements. The weighting necessary to lump irrigated pasture, alfalfa hay, supplements, and aftermath could then be approximated; and a single input reflecting forage or feed might be used. The problems are just as severe in the land and capital resources of the ranch.

Management input defies measurement, let alone a standard unit. The ranching industry is characterized by divergences in management techniques. Absentee owners, owner operators, and parttime operators have different approaches and abilities for management. In most cases, a portion of the unexplained variability can be attributed to entrepreneurial ability. Some researchers even argued that variations due to management ability are so severe that empirical production functions cannot be estimated with cross-sectional data (Walters 1963).

Another problem common to all approaches regards the statistical significance of the input of different forages. For instance, if one desires to determine the demand for Federal forage, what will happen if Federal forage is not a significant variable in the production process. This will likely be a data-related problem where significance would be found if additional and more precise data were available. The pseudo-data approach, where additional data can reasonably be obtained, may avoid this problem.

The definition of a production technology requires detailed information on quantities of inputs and outputs, additionally the dual and market approaches require prices. The lack of complete information on all inputs is specifically evident in the lack of a price for Federal forage. Obtaining physical input use is difficult and involves considerable estimation of quantities.

Another problem centers around the use of all capital assets at full capacity. Many of the survey approaches to data collection merely enumerate the items used, or owned, by the ranch. The partial use of a capital item results in a bias away from the most efficient production frontier. This introduces another variable with stochastic properties which must not be neglected.

Direct Estimation of Production Functions

The direct estimation of production functions has a long history in agriculture. Early work incorporated the popular Cobb-Douglas, Spillman, and quadratic production functions (Heady 1961), although later work introduced comprehensive functional forms such as the constant-elasticity-of-substitution (CES) and the generalized constant-ratios-of-elasticity-of-substitution-homothetic (CRESH) functions (Hanoch 1971).

The structural forms of the production relationships for ranching are not well understood. The majority of the work relating to the whole ranch production relationships has centered around linear programing formulations. Here, various alternatives are formulated and selection depends on constraints and price relationships. This represents a series of activities that are combined to form the entire ranch production process. These activity-related processes do not lead directly to the specification of multiple-output production functions. The determination of enterprise production functions may lead to simultaneous equation production relationships. A model of this type has been proposed by Johnson (1971). His model consists of the aggregation of individual "micro-functions" (which represent the basic units of farm production, breeding cow, breeding ewe, crop acre) into a whole-farm production function. The extensive data necessary to estimate the models he has proposed have prevented application.

The statistical estimation of production functions requires the level of physical inputs and outputs measured for a production process. Price information on outputs and inputs is not required during the estimation process. This contrasts with the dual

approach and represents a strength when considering non-market inputs and outputs.

The direct estimation approach has been applied with varying degees of success on agricultural operations (Walters 1963). The studies to date involving estimation of livestock production have primarily been on feedlot systems, where experimental designs have studied the feeding process. Trosper (1978) studied the ranching efficiency of Indians and whites in Montana through the use of production (and profit) function estimation. He aggregated inputs to three (land, labor, and capital) and utilized a single output (cattle sales + change in inventory + family consumption). The level of factor aggregation results in derived demand possibilities for only three inputs, thus the study did not determine the derived demand for forage.

Most empirical work with production functions has assumed a single, homogeneous output. The result of this is to derive either enterprise (corn, hay, hogs) functions or employ a common unit of measure (dollars or pounds of beef) to convert all outputs prior to derivation, such as Godfrey proposed. Using a common unit of measure restricts the output to price ratio to a constant for all outputs during the projection period.

Once a production function is specified using Federal forage as a unique input, demand can be determined. Derived demand for Federal grazing is obtained by simply finding the value of the marginal product for Federal grazing.

Dual Approach to Derived Demand

This approach involves the estimation of the parameters within the derived input demand and output supply functions (relations (4) and (5)). This implies the use of a profit function. Lau and Yotopoulos (1972) state three advantages in working with profit functions as opposed to production functions. First, it allows the derivation of output supply and input demand functions directly from an arbitrary profit function with known properties. This provides great flexibility to the researcher in that restrictions regarding substitution and output relationships are determined rather than imposed through a restrictive function. This contrasts with linear programing formulations which permit implicit substitution in inputs through alternative activities. In the direct estimation of production functions, the restrictive properties of the substitution parameters are known and specified prior to analysis of the data. Second, by starting with the profit function, it is assured through duality that the resulting system of supply and factor demand functions is obtainable from profit maximization by a firm under competition. Third, the estimated relations are functions of variables that can normally be treated as exogenous. That is, input and output prices can be taken as exogenous, and therefore estimation is less complex. By estimating these equations directly, the problem of simultaneous equation bias can be avoided. They further state that the estimation procedure should consider the supply and demand functions jointly as they will contain common parameters and restrictions should impose equality on the common factors. The estimation procedure should also consider the possibilty of errors correlated among different equations.

The major difficulty in applying this procedure to the ranching industry is data related. Necessary information for estimation includes not only the prices of outputs but also the associated prices of inputs. Thus, for each input specified, a corresponding price must be determined. For highly aggregated inputs such as capital, a weighted or average price or index corresponding to the combined inputs must be determined. As an input Federal forage must also have an associated price, which is not readily available nor without controversy.

In applying this procedure, the problem of multicollinearity becomes readily apparent. If cross sectional data were to be used, the assumption of competitive markets would necessitate estimation across several markets to provide variation in prices among inputs and outputs. This restriction results in examination of cross sectional data from a multiregional perspective. The problems become less severe when time series data are employed. The multicollinearity problem still exists and could be restrictive if prices change very little over the time series or if prices move at nearly the same rates (which might be expected from ranching data, especially for highly aggregated inputs).

This approach has been applied to agricultural data primarily at the national level. Yotopoulos and others (1976) found that the agricultural sector of Taiwan was better explained through supply and demand functions than direct production functions. Ray (1982) examined the U.S. crops and livestock industries using duality theory to explain substitutability between capital and labor. On a firm level, Trosper (1978) also used this approach to examine questions concerning efficiency of production of Indians and whites involved in ranching in Montana.

Pseudo Data Approach

The problems encountered due to lack of relevant input price data for Federal forage raise questions as to whether the duality

approach has application in determining Federal forage demand. The psuedo data approach may prove useful in assisting where data shortfalls exist. The data used in statistical estimation for this procedure are generated by an optimization model. Data point; "pseudo data," show the optimal input and output quantities corresponding to vectors of input and output prices. Through repetitive solutions to the optimization model for alternative price vectors, the shape of the production function is determined. The pseudo data representing the optimal combinations are then used to estimate the input demand and output supply functions of the profit function.

Griffen (1977, 1978) has applied this technique to the petrochemical and electrical power generation industries. He cites three principal advantages. First, the technical specification of the production surface is not limited by the historical relative price variations or environmental practices. Second, the production response surface is differentiable and can therefore be a convenient source for point elasticity estimates. Third, the cost or profit functions derived can be readily differentiated to yield estimates of input-output coefficients. The use of pseudo data techniques in the generation of input-output coefficients is demonstrated in Finan and Griffin (1978).

The pseudo data approach could prove useful in describing the production process which linear programing optimization models in ranching imply. Provided a useful production relationship could be derived, forage demand, technical efficiencies, substitutability, and elasticities could be estimated and provide better understanding into the implied relationships of the linear programing model.

Econometric Market Models

The use of econometric techniques to estimate parameters within market models is common in macroeconomic studies. Its application to natural resources has been demonstrated through the Timber Assessment Market Model (Adams and Haynes 1980). These models are characterized by simultaneous relationships representing supply and demand with the more complex models handling transactions between regions within the same solution. The Timber Model has met with much success and been held as the example to which all major resource outputs within forest planning should aim.

Essentially there have been no attempts at econometric estimation of forage market models (Godfrey 1981). The lack of an active market where AUM's of Federal forage are exchanged places a special burden on the analyst attempting market models for forage. Regional timber market models (for example, McKillop 1969) existed for some time prior to the implementation of a successful spatial market model. This appears to be a logical step for range forage modelling.

SUMMARY

The absence of a competitively determined market price for forage from Federal lands has necessitated the use of indirect techniques to estimate demand and forage value. Demand has been estimated through optimization studies utilizing mathematical programming techniques or point estimation of demand through comparable private lease rates, alternative forage sources, or capitalized permit values. These approaches are extremely sensitive to the underlying analyst's assumptions and result in considerable disagreement among studies.

Econometric analysis provides an alternative approach to demand estimation which has not been widely employed. These methods are not restricted to single output estimation and can be applied to the demand for forage at the market (regional, national, etc.) or the firm (ranch) level. The estimated elasticities and substitution rates are not necessarily predetermined by the assumptions the analyst employs.

Econometric techniques which might prove useful in the estimation of forage demand include the direct estimation of production functions, estimation of ranch output supply and input demand functions from primary data or pseudo data sources, or the estimation of market models for forage. The problems associated with the use of econometric techniques in the ranching industry are not trivial and are primarily data related.

The primary advantage to direct estimation of production functions is the lack of need for prices, while the disadvantages are the required (and restrictive) functional form and the possibility that insufficient data may result in non-significance for Federal forage as an input. Input and output prices which reflect variation are required for the dual approach, and non-significance of Federal forage is a possibility. The primary advantage of the dual is that no predetermined and restrictive form for the production function is needed. The pseudo data approach is advantageous in that the price variation is not restricted to the historical range of values. It is, however, limited in that it explains only what the generating model provides as output. Thus, the success of the pseudo approach depends on the successful modelling of the production unit initially. Econometric market models are restricted in applicability because competitive Federal forage prices are not available. Modelling the substitutes and

complements of Federal forage may be successful.

Econometric application requires the specification of structural forms for the production relationships, data aggregation and separation decisions, and the possible estimation of multi-product production functions. The relationships which result may involve relatively few exogenous and endogenous variables, compared to optimization studies, and data collection techniques may be simplified. Once the ranching industry is comprehended in this detail, forage demand may become less expensive to estimate and better understood.

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LAND USE SHIFTS IN THE GREAT PLAINS:

NEEDED INTERREGIONAL ANALYSIS OF POTENTIALS FOR

AND COMPARATIVE ADVANTAGE IN GRAZING AND CROP PRODUCTION

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INTRODUCTION

This paper suggests a hypothesis to explain land use shifts in the Great Plains which may accompany expanding agricultural production. Demands for private cropland, pastureland, and rangeland implicit in projected increased domestic consumption and exports contain a seeming inconsistency that may actually represent complementary production of crops and livestock. Shifts in private land use also have implications for public land management. The Intermountain Region, immediately adjacent to the Great Plains, will likely be affected by agricultural price and technology changes which alter the latter's comparative advantage in production.

The U. S. Department of Agriculture (1981, 1980) has published two analyses of present and potential productive capability of this Nation's private and public lands respectively. These studies were required by the Resources Conservation Act (PL95-192) and Resources Planning Act (PL93-378), respectively. These analyses were driven by projected increases in technology, domestic consumption, and exports. The index of agricultural productivity (1967 = 100) was projected to increase from 116 for the years 1975-77 to 147 and 187 in the years 2000 and 2030, respectively. By 2030, domestic beef and veal consumption would increase 17 percent while consumption of corn and wheat would expand 68 percent and 13 percent, respectively. For the same years, the export index was projected to increase from 169 to 290 and 351. Although not strictly comparable, an index of range grazing demand (1970 = 100) was projected to reach 185 by the year 2030.

The projections outlined above translate into a cropland production base of 457 million acres. In 1977, there were 413 million acres of cropland and 127 million acres of pastureland, rangeland, and forestland with high or medium potential for conversion to cropland. By 2030, 44 million acres will be converted to urban and other non-agricultural uses leaving 369 million acres of the present cropland base intact. Consequently, 88 million acres of privately owned pastureland, rangeland and forestland will have to be converted to cropland. Figures in Table 1 provide an idea of the domestic consumption and export increase mix which lies behind the index figures.

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The shift of 88 million acres from range and pasture to cropland appears to be a substantial change. It might be asked if such a change would be seriously disruptive. Hansen's (1982) analysis of national land use patterns in Britain, Canada, and the United States sheds some light on this and related issues. He suggests that land use patterns have been shifting along a spectrum with changes in the United States not near either tail of the distribution. If this evolutionary adjustment process continues to work, future conversions are likely to be reasonably orderly.

Urbanization of 44 million cropland acres and conversion of 88 million acres from rangeland is a small production and use pattern shift in a 2 billion acre land base. However, such a shift may be unevenly distributed among subregions. In his article Hansen also noted that competition between agricultural and other uses in rural areas is stronger than that which shifts agricultural land into urban uses. Further, declines in specific agricultural uses are due as much to competition from other agricultural uses as to competition from non-agricultural rural uses.

Table 1.--Projected national increase in domestic consumption and export of selected crops and livestock in 2030 above the 1975-77 base.

Product	Projected Increases Domestic Consumption	Exports
	------Percent------	
Beef and Veal	17	
Barley		106
Corn	68	84
Sorghum		77
Wheat	13	122

Source: United States Department of Agriculture, <u>1980 Appraisal, Part II, Soil, Water and Related Resources in the United States: Analysis of Resource Trends,</u> August, 1981.

GREAT PLAINS LAND USE

Selected national projections of domestic crop and livestock consumption and export between 1977 and 2030 were summarized in Table 1. The Great Plains Region (North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas) has always been a

stable major supplier of these products.[1] In the 1975-1977 base period its shares of U. S. barley, corn, and sorghum production were 29 percent, 16 percent, and 86 percent, respectively. Regional shares of total winter, durham, and spring wheat production, respectively, were 47 percent, 78 percent, and 51 percent. As shown in Table 2 the regional shares of national livestock production have occurred with very little apparent aggregate land use shifts in the ten-year period as Table 3 illustrates.

To bring the impact of projected national land use changes on the Great Plains into focus, consider the following. Nationally, private pastureland, rangeland, and forestland acreages which can be cropped include 36 million acres having high and 91 million acres with medium conversion potential.[2] About 70 percent will have to be converted to meet projected 2030 crop production for domestic consumption and export. Given input costs and emphasis on soil conservation, one may expect the 36 million acres having high potential will be converted first and 52 million from medium potential taken thereafter.

Table 2. --Great Plains region's shares of U. S. livestock.

Livestock Category	Regional Shares 1969	1974	1978
	--------Percent-----------		
Cattle and calves	30	30	32
Beef cows	37	33	34
Heifers	30	30	31
Steers	34	34	38
Sheep and lambs	39	38	39
Ewes	40	41	39

Source: Calculated from Censuses of Agriculture.

Table 3.--Selected great plains agricultural land use allocations measured as percentages of total land in farms in the region and nation*

Use Categories	Proportions of Regional & Natl. Uses 1969 GP	1969 US	1974 GP	1974 US	1978 GP	1978 US
			Percent----	----		
Total cropland	45	16	44	16	45	16
Cropland used only for pasture or grazing	7	3	7	3	7	3
Pastureland and Rangeland	49	18	50	18	50	18

*Percentages $\frac{\text{GP Category Acreage}}{\text{GP Land in Farms Acreage}}$

$\frac{\text{GP Category Acreage}}{\text{U. S. Land in Farms Acreage}}$

Source: Calculated from Censuses of Agriculture.

The National Agricultural Lands Study (1981) on competition for agricultural land reported acreages available for conversion to cropland.[3] Each of the states, except North Dakota, has over 1,000,000 acres of pasture and native pasture with high or medium suitability for use as cropland. North Dakota contains between 500,000 and 1,000,000 acres of pasture and native pasture with high or medium suitability for use as cropland. North Dakota contains between 500,000 and 1,000,000 acres. Using the lower value in these categories, conservatively at least 5.5 million acres of pasture and over six million acres of rangeland with high and medium conversion potential are found in the six Great Plains states. More recently, the ERS Great Plains Project (1982) estimated 7,106,000 acres of pasture and rangeland with high conversion potential, and 17,582,000 acres with medium potential.[4] The six-state total is 24,688,000 acres. If regional conversion at least mirrors national projections, 70 percent of this base will be needed. Between 8.1 and 17.3 million acres may eventually be converted to cropland. Simultaneously, USDA (1980) has projected a 61 percent increase in grazing demand for the region, suggesting direct competition between grazing and crops for land.

Substantial intra-regional use shifts have already occurred, which cannot be detected by looking just at regional land use figures. These shifts could lead to serious difficulties in making future adjustments. As Table 4 demonstrates, production of both cattle and grain on the same farm/ranch is a still important but decreasingly common practice. Further, Table 5 indicates that by 1978 beef cattle production had been concentrated in fewer and fewer operations holding larger herds. It may be inferred that although the land use allocation percentages do not show it, most grain and livestock production is happening on operations specializing in one or the other. It would seem at

[1]Usually, the eastern parts of Montana, Wyoming, Colorado, and New Mexico are also considered to be in the Great Plains. Studies cited in this paper restricted this definition to maintain state boundaries intact.

[2]SCS/USDA, 1977 National Resource Inventory, Washington, D. C. The lands considered highly suitable require no special treatment to avoid wind and water erosion. Medium suitability indicates one or more problems may exist which require special care.

[3]The NALS reported conversion categories of 300 to 500 thousand, 500 thousand to one million, and one million acres plus.

[4]ERS/USDA, Implications of Expanded Agricultural Production for Agricultural and Natural Resources of the Great Plains, Natural Resource Economics Division Research Project Plan of Work, 1982.

first glance that further production adjustments, and particularly output expansion, must come at the expense of either crops or livestock. In a region that nearly fully utilizes its land can a 61 percent increase in grazing demand and conversion of between 8 and 17 million acres of pasture and range into cropland be accommodated simultaneously?

Table 4:--Percent of farms producing both grain and beef cattle in the Great Plains.

State	1969	1974	1978
	---------Percent	------------	
North Dakota	63	53	43
South Dakota	70	55	51
Nebraska	70	54	47
Kansas	78	57	48
Oklahoma	89	42	28
Texas	20	16	4
REGION	57	42	30

Source: Calculated from Censuses of Agriculture.

Table 5:--Percent of farms holding and percent of cattle and calves held in herds of 100 or more in 1978.

State	Farms	Cattle and Calves
	------Percent	-------
North Dakota	31	67
South Dakota	41	80
Nebraska	35	82
Kansas	29	78
Oklahoma	24	70
Texas	23	77
REGION	28	77

Source: Calculated from Censuses of Agriculture

LAND USE CHANGE RECONSIDERED

At first it seems improbable that crop and livestock demands projected for the Great Plains can be met simultaneously on the region's fixed land base. But, meeting these projections may be feasible if useable aftermath accompanies crops grown on converted grazing lands. Expansion of the cropland base might not reduce feasible livestock production and could even make expanded production feasible.

Complementary crop and livestock production is possible and Table 6 indicates it already occurs in several regions of the country. It also has to be economic for producers.[5] Crops and livestock must each make positive returns before farmers and ranchers will take advantage of the complementary nature of crop aftermath in livestock production. They can also do such in several ways. Complementary production can be organized with operators producing both crops and livestock, growing crops and selling aftermath, or raising livestock and purchasing aftermath.

LAND USE FRAMEWORK

Land use conversion to crops that takes complementary forage production into consideration works along the following lines. Pasture and rangelands are converted into croplands. Crops grown may produce aftermath which offsets grazing lost. If range forage is in excess supply, while other feeds are unavailable at times in the grazing year, aftermath may solve the timing problem and could lead to expanded livestock production.

For purposes of the following discussion agricultural land is defined as cropland plus rangeland. Rangeland includes all improved and unimproved areas devoted exclusively to producing grazed forages. Two situations are analyzed. In the first case all agricultural land is utilized and production technology is constant. The second case allows technology to change. For simplicity it is assumed any acre can be used as range or cropland. Conversion costs are assumed to be constant per acre. The cropland is used to produce grain, and the rangeland grazed forages. The price received for each is independent of the other.

[5] Risk may also impose limits. Various levels and combinations of products imply capital/output and capital/labor ratios which are measures of productive efficiency and relative input use, respectively. The ratios observed along a production frontier define technical feasibility. Beyond efficiency, utilization, and technical feasibility ratios can also provide information about uncertainties. In some instances an above average or higher capital/labor ratio may indicate mechanization to avoid uncertainties in labor markets. A low ratio might imply high labor use to avoid capital costs or an aversion to debt. Limited alternate employment possibilities are also a consideration.

Table 6:--Grazing use by forage type for ranches in selected regions of the United States.

Grazing Regions	Types of Forage Grazed: Private Range	Rented Pasture	Grain Pasture	Crop Residue	Total
Intermountain					
Acres per ranch	1,561	620	--	186	2,397
Percent of total	65	27		8	100
Northern Great Plains					
Acres per ranch	1,141	440	--	220	1,801
Percent of total	63	24		13	100
Southern Great Plains					
Acres per ranch	1,838	958	270	81	3,147
Percent of total	58	30	8	4	100

Grazing Regions	Types of Forage Grazed: Pasture	Warm Grass Pasture	Cool Grass Pasture	Crop Residue	Total
Corn Belt					
Acres per ranch	210	160	215	58	648
Percent of total	32	24	33	11	100
Southeast					
Acres per ranch	203	199	98	150	650
Percent of total	31	30	15	24	100

Source: FEDS Budgets for 1977, NED/ESS/USDA, Stillwater, Oklahoma, 1981.

Constant Technology

In this hypothetical case all land is employed in the production of grain and forage. As shown in Table 7, grain yield per acre is constant while forage yields decrease in a steady "stair step" fashion. With this information it is possible to directly calculate acreage used, given production, or vice versa, for each product separately and both together. When a use shift occurs, operators will distribute land conversion in a pattern that minimizes the opportunity cost of output foregone.

The transformation relationship is shown in Figure 1. Initially product prices are such that 12 tons of grain and 22 AUM's of forage are to be produced. This is indicated by P_1 in Figure 1 which represents production frontier tangency with the inverse grain/forage price ratio. At this price ratio 12 acres are devoted to grain production and 8 acres to grazed forage production.

Now suppose an exogenous rise in grain price occurs due to increased export demand. This changes the price ratio in Figure 1 to P_2. The new level of grain production is 16 tons. The price ration change translates into 16 acres of cropland, four acres of which being converted from rangeland with a loss of 10 AUM's.

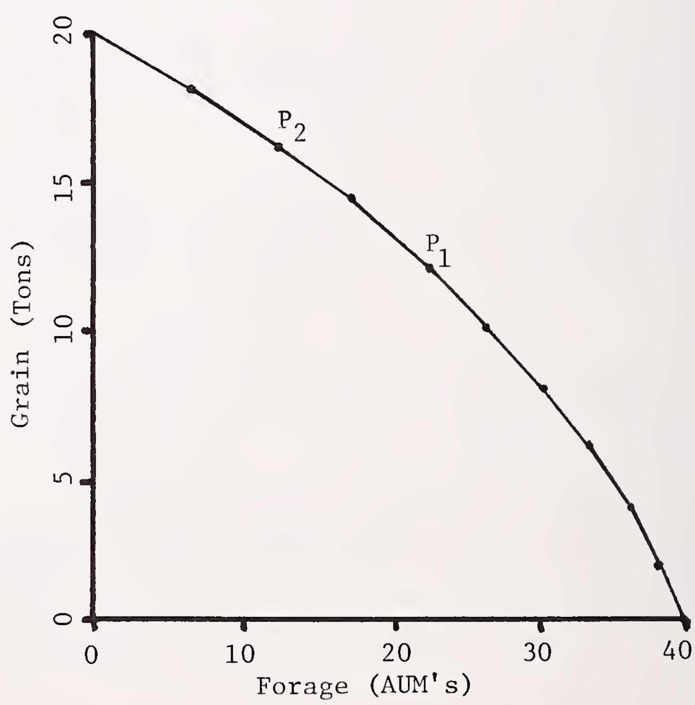

Figure 1.--Hypothetical grain/forage production possibilities

Table 7.--Hypothetical agricultural land productivity when used in grain or forage production with all land in production.

Agricultural Land					
Cropland			Rangland		
Acres	Tons	Marginal Ton/Acre	Acres	AUM's	Marginal AUM/Acre
0	0	1	0	0	3.0
2	2	1	2	6	3.0
4	4	1	4	12	2.5
6	6	1	6	17	2.5
8	8	1	8	22	2.0
10	10	1	10	26	2.0
12	12	1	12	30	1.5
14	14	1	14	33	1.5
16	16	1	16	36	1.0
18	18	1	18	38	1.0
20	20		20	40	

Agricultural land in rangeland is reduced from 8 to 4 acres and grazing from 22 to 12 AUM's. Suppose, however, a contract had been signed guaranteeing production of the original 22 AUM's. Either export income would have to be foregone or additional forage located. If grain can be planted which also yields 2.5 AUM's Acre in aftermath, lost grazing could be replaced and no income foregone.

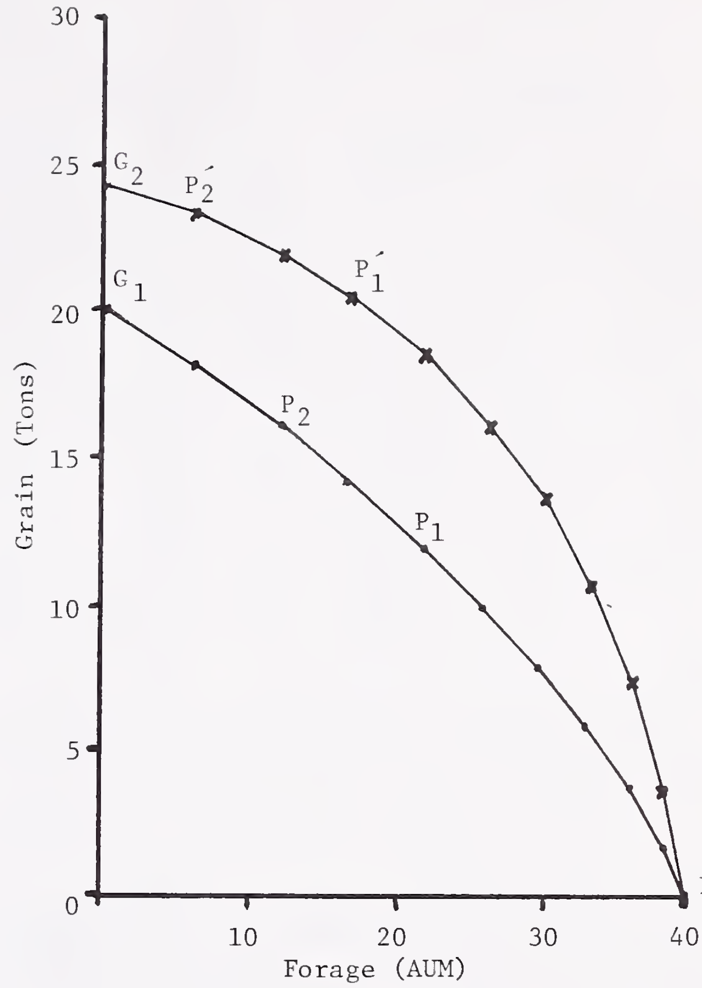

Figure 2.--Hypothetical grain/forage production possibilities following technological change in grain production.

Variable Technology

In this example technological advance is allowed. Full utilization of agricultural land continues. Both production efficiency and price increases for grain appear. Forage price and production technique remain the same. Table 8 lists the new grain production levels possible. The forage production possibilities remain as before. In Figure 2, FG_1 is the old production possibilities frontier. FG_2 is the new frontier due to technological change. The agricultural land acreage remains the same. Again, P_1 on FG_1 represents the original tangency of the price ratio inverse to the old production frontier. After increased production efficiency shifts the frontier outward and grain price increases due to additional export demand the tangency point of the new inverse price ratio is P_2' on FG_2. At this point 23.25 tons of grain are produced using 18 acres of cropland and 6 AUM's of forage on 2 acres of rangeland. Overall, land in crop production increases by six acres (from 12 to 18) while that in rangeland decreases a like amount (from 8 to 2 acres). The gain of 11.25 tons in grain requires giving up 16 AUM's of forage.

The change in production mix can be decomposed into the part due to technology change and the part due to price range. Point P_1' represents a tangency of the old inverse price ratio to the new production possibilities frontier. The vertical distance between P_1 and P_1', representing a 8.5 ton increase in grain production and two acres shifted from range to cropland, is that part of the total output mix change due to technological advance. The vertical distance between P_1' and P'_2 represents an additional change of 2.75 tons of grain grown and four acres shifted from range due only to price change.

Compensating Aftermath Production

Projected increases in domestic beef, veal, and grain consumption and in grain export were mentioned earlier. Increasing grain production could prevent expanding domestic livestock output to meet projected consumption increases unless a compensating factor was at work. This factor could be grazable aftermath. The rate of per acre compensating aftermath production necessary depends on the acreage converted from rangeland to cropland as shown in Table 9. The example represents only aftermath carrying capacities required to produce 40 AUM's when

Table 8.--Hypothetical agricultural land productivity following technological change when used in grain or forage production with all land in production.

Cropland			Rangeland		
Acres	Tons	Marginal Ton/Acre	Acres	AUM's	Marginal AUM/Acre
0	0	2	0	0	3.0
2	4	2.75	2	6	3.0
4	7.5	1.625	4	12	2.5
6	10.75	1.5	6	17	2.5
8	13.75	1.25	8	22	2.0
10	16.25	1.125	10	26	2.0
12	18.5	1.00	12	30	1.5
14	20.5	.75	14	33	1.5
16	22.0	.625	16	36	1.0
18	23.25	.50	18	38	1.0
20	24.25		20	40	

Table 9.--Per acre AUM production required from aftermath to maintain forage production at the level before agricultural land was converted from range to cropland.

Acres Converted to Cropland	AUM's lost due to Conversion	Aftermath AUM's Needed Per Acre
20	40	2.00
18	34	1.88
16	28	1.75
14	23	1.64
12	18	1.50
10	14	1.40
8	10	1.25
6	7	1.16
4	4	1.00
2	2	1.00
0	0	0.00

starting with all agricultural land in range.[6] Similar tables could be constructed for other cases. Per acre production of aftermath AUM's needed depends solely on the number of acres converted to cropland and the range's carrying capacity.

Analytical Limitations

The model framework and hypothetical examples discussed are deterministic. Implementing the framework to study agricultural production and land use would require statistical treatment of both between-year and within-year variation. These variations are derived from a number of sources. First, there is year-to-year variability in range and pasture outputs and aftermath available. Range and pasture outputs depend on uncontrollable outputs like fertilizer and irrigation. Aftermath available for grazing is determined by crop production levels, harvesting techniques, and weather after harvest. The first two determine the amount of forage available. Weather after harvest determines how long the aftermath is usable. If clear weather prevails, extended grazing is possible. Heavy rain or a lengthy snow fall will make aftermath unusable. Second, there is within-year variability in forage supplies which differs for each source of grazing. Range production is inherently most uncertain due to general weather changes and previous grazing pressure. Dryland pasture may be somewhat less variable. Irrigated pasture is relatively unaffected except for temperature shifts. Within-year aftermath variability is due to the same factors that induce uncertainty in output levels between years.

LAND MANAGEMENT PROGRAM IMPLICATIONS

The previous discussion was based on a hypothetical case. Although the values and relationships were assumed, they may reflect the relationship between livestock and crop production in the Great Plains. Livestock production in this region does not exist in a vacuum. Inevitably, changes in the Plains will be felt in other producing regions and vice-versa. This tie between regions is determined by comparative advantages based on resource endowments and location with respect to markets. In the following two subsections

[6] The figures in Table 9 are based on the hypothetical example shown in Table 8. The per acre rate would be higher when starting from a point at which both grain and forage are being produced because range forage production is variable and the example was set up with lower producing acres converted first.

implications of the model for livestock output in the Great Plains and Intermountain Regions are developed. The private and public sectors are discussed separately.

Private Sector Implications

To the extent aftermath acts as a complement in production of livestock, the competitive position of agriculture in the Great Plains and incomes of individual farmers and ranchers will be enhanced. Resources will be more fully utilized and the region's comparative and absolute advantages increased. How this increase occurs will greatly affect ranching in the Intermountain Region. Consider cattle as an example. Most Intermountain ranches are cow-calf operations heavily dependent on public grazing. This grazing supply is fixed in extent by laws, administrative regulations, and agency budgets. If cattle production in the Great Plains expands in the direction of calf production, the Intermountain Region could suffer. If, on the other hand, the expansion favors feeder or grass fat production, a larger market for calves from the Intermountain area might develop. In the extreme it could even prove worthwhile for public land based operators to develop alternative forage sources to expand their resource base and productive capacity.

The structure of Plains agriculture, as characterized by the size distribution of production units, will be important to these adjustments. Examination of the Census of Agriculture suggests 77 percent of the region's beef cattle are held in herds of 100 animals or more by only 28 percent of the farms. While crop and livestock production are carried out simultaneously on many farms the number has been falling steadily. If rangeland conversion to cropland occurs, grazable aftermath may be a complementary product. But, the extent to which conversion followed by grazing is practiced can differ among farm size classes. The likelihood and geographic pattern of this kind of resource management are unknown. The economic and sociological characteristics and their interrelationships, which can be used to predict aggregate rates and extents of adjustments made, have yet to be identified and quantified. Until that is accomplished estimates of conversion impacts and risk issues will not be as accurate as necessary for decisionmaking purposes.

Public Sector Implications

Government agencies have programs directed at private landowners and at private and public land management. How efficient these programs prove to be depends in part on landowner responses to changes in relative prices of crops and livestock and land use conversions which are part of those responses. Conversion to cropland in the Great Plains could reduce pasture and range improvement program efficiencies. When it is to the landowner's economic advantage, conversion of grazing land to cropland occurs. Public funds invested in grazing improvement may be lost. If so, return on investment, length of projects' lives, and induced impacts will decrease. Alternatively, depending on crops planted, conversion to cropland can also produce preharvest and aftermath grazing. (Winter wheat is grazed extensively in Oklahoma and Texas.) But, the level of grazing which can occur without soil degradation over time must be a consideration. This new aftermath grazing source could either provide enough fodder to maintain herd sizes or actually lead to expanded livestock numbers in the face of rangeland conversion.

A major issue for public land management is program efficiency. If the Great Plains Region's absolute and comparative advantages both increase and cow-calf production goes up, the competitive position of public land based livestock producers may erode. Range investments already completed will yield lower returns than previously projected. If programs call for investment increments being added in the future, those not already on-line will have to be reevaluated. They may be reduced or eliminated entirely. At the opposite extreme increased feeder and grass fat production in the Plains could open new markets and lead to expansion of investment programs on public lands.

The second issue is regional advantage in adopting technology. This paper deals with the Great Plains land use conversion at a regional level. The Intermountain region is more heterogeneous by comparison and will be variously impacted, accordingly. It might have fewer alternative uses for its land and even more limited supplementary or complementary production possibilities. Response to positive externalities may simply be infeasible.

At the micro level special attention will have to be paid to insure that public land management decisions are as nearly neutral as possible with respect to viability of individual ranchers. There could be situations in which decreased public activity drives ranches out of operation because the threshold between economic and non-economic sized units is narrow. Determining the effect of reduced public programs must take this narrowness into account or the real financial cost incurred will be underestimated. For example, since publicly owned resources are capitalized into the asset value of individual operations, reduced or eliminated programs can redistribute wealth away from their owners but not correspondingly increase the wealth of other individuals.

ANALYTICAL FRAMEWORK

Some major issues associated with agricultural production and land use conversion have been presented. Statistics on past and present use and projections of future production imply conflicting simultaneous demands. This conflict could be illusory. Movements between and along the extensive and intensive margins of production may resolve it.

At present, the implications drawn remain speculative. Their validity is of particular concern to the private and public sectors involved in regional livestock production and administration

of private and public domain grazing lands.[7] A research structure to provide information to deal with the issue is suggested below. It involves a sequency of three topics and associated analytical techniques.

Regionalization

The most recent USDA Appraisals were based on regions which have not been tested for statistical validity. A new regionalization of the United States is necessary which recognizes present physical, political, socioeconomic, and biological factors. Regions should be defined that are homogeneous with respect to these factors, using statistical techniques and individual time-series observations of each at the county level. The regional definition should be repeated in every census year to approximate the dynamics of national adjustments.

Production Adjustments

It was mentioned earlier that producers will expand complementary production of livestock and crops only if economic incentives to do so exist. Sufficient data are not available to determine the present extent of such production (relative to capacity) by individual operations and whether it is optimal. However, county level time-series and cross-sectional data on production, input, and land use is available at five year intervals in the Census of Agriculture. Annual compilations from the Statistical Reporting Service provide information on grain and forage crops, crops which provide aftermath grazing, and numbers of livestock by class. USDA Forest Service, ERS, and State Cooperative Extension Services provide data on production costs and associated levels of grazing. These various data can be combined to define historic production, associated costs, and land use patterns.

Several national models exist which can be used to calculate historic regional production patterns which would have been optimal in annual, five, ten year, or other intervals. Shift-share analysis will give some indication of how interested operators are in adjustments necessary to optimize income.[8]

The data series mentioned also show the number of farms producing crops, the number of farms producing livestock, and the total number of farms in each county. When the sum of the former two exceeds the total complementary production is occurring. Statistical tests may be applied to determine if significant changes have happened across space or through time and whether there are causal relations with land use changes.

Comparative Advantage

Production functions characterize technology in place. Enterprise budgets, which are now available for most regions, represent a point on a production surface. Other points can be represented by varying the amount or the mix of inputs used in a production process. Even in the absence of functions, as several points become available, production possibility frontiers begin to be known. Alternative budgets may be estimated for subregions of the Great Plains and Intermountain Regions, or as aggregates for each using data drawn from sources listed previously. These budgets can be used to describe grain/forage production possibility frontiers and lead to better analyses of short and long-term adjustments in response to crop and livestock price shifts.

Shifts in absolute and comparative advantage, due to grazing crop aftermath, can be analyzed using these relationships. This may lead to explanation of more than just land use change. When sufficient information becomes available, marginal conditions can be derived and equated. Then, how closely efficiency is being approximated can be determined.

SUMMARY

A production and land use model and analytical approach has been suggested to evaluate what appear to be contradictory projected demands for crops and livestock. Research may reveal that implied land use conflicts actually represent complementary production of crops and livestock. If so there are major implications for public and private range and pasture management and improvement programs.

An interregional analysis is needed to determine the effects of forces, driving land use shifts, on private and public land management. The analysis involves: (1) A statistical regionalization scheme for the United States; (2) a more detailed look at production patterns over time and across space, including examination of land use patterns to identify components which affect interregional comparative advantages; (3) A production alternatives approach to estimating production possibilities frontiers and their economic implications.

[7]It must be briefly noted that while the problem involves western regions, it also has national ramifications. These arise from equity considerations. The western range livestock industry developed in response to social policy that promoted settlement of the nation. Title to land was granted in return for taking risks associated with settling an area which was inamicable by eastern standards. This question has and is being addressed elsewhere.

[8]Unless effects of the cattle cycle and technological change are washed out results will be indications only, not firm statements.

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ISSUES AND PRIORITIES FOR RANGE ECONOMICS RESEARCH

Carlton A. Infanger

ABSTRACT: Federal land policy has left a legacy of range issues that require economic analysis. The issues include: ownership, non-market outputs, ecology, management levels, distribution of benefits, and how to achieve objectivity in research. Research priorities include determining which projects will yield the greatest social returns, guiding technical research to get data useful to management, and how to allocate resources to competing uses.

INTRODUCTION

Any attempt to discuss the issues and priorities for range economics research must recognize an historical background of land settlement that was not conducive to building viable ranch units or good land stewardship. Why these conditions developed was described by Hibbard as "...a series of expedient actions put into practice from time to time...and called public policies..." (Hibbard 1965). While Hibbard may have been close, historians do not completely agree on why and/or how this nation--whose basic ideologies and institutions are rooted in private ownership--came to maintain large blocks of publicly administered lands within local government boundaries. A general consensus seems to include (1) a failure of the congress to recognize the type and size of private holdings that would be needed for economic units and (2) the development of a conservation movement as the land base was being exploited and destroyed while held as a "fugitive" resource.

Two major pieces of legislation, the Organic Administration Act of 1897 and the Taylor Grazing Act of 1934, moved federal land ownerships out of the non-mutually exclusive phases of acquisition and disposal into the equally non-exclusive reservation and management eras. Following the political and legislative struggles which led to the creation of the Bureau of Land Management in 1946, Peffer made a strong case that the public domain was "closed" (Peffer 1951). That it was closed and the new era of management was being ushered in was emphasized by the passage of the Federal Land Policy and Management Act of 1976 (FLPMA). That the issue of federal vs. state and/or private ownership was still very much alive was manifest in the "Sagebrush Rebellion" as a reaction to FLPMA.

If management of federal lands is now enthroned, the question of managed to what ends, and for what goals, becomes paramount. The basic Forest Service guide is the famous "Pinchot Letter" signed by Secretary of Agriculture, James Wilson, on the same day that President Roosevelt signed the Transfer Act. This letter emphasized management and use and the permanence of the forest resources of wood, water, and forage. (Alston 1972) The Taylor Grazing Act gives similar direction to the management and use of BLM-administered land when, in its preamble, the objectives of stopping injury to the public lands, providing for orderly use and improvement and stabilizing the livestock industry are set forth. (Calef 1960) While these serve as general guidelines, they leave many unanswered technical questions, promote political debate, and raise questions of economic efficiency.

A review of current literature on range research gives some idea of the myriad of interrelated biological, technical, and economic questions the heterogeneous range ecology gives rise to. Moreover, those who would manage this composite range resource need the answers to these involved questions within an equally complex framework of political pressures that come from a variety of public and private interests. This diversity of interests brings forth a number of issues that need to be considered and dealt with if proposed goals are to be reached.

ISSUES

Each paper given at this conference deals with one or more issues. No doubt each participant has others that he or she might like to add. Let me suggest six broad categories that seem to consistently surface in the literature and public press: (1) ownership of range resources; (2) market vs. non-market outputs; (3) ecology and conservation; (4) levels and type of management; (5) distribution of rangeland benefits; and (6) objectivity in research.

Ownership

While I indicated in the introduction that the nation appears to be moving or has moved toward an era of management of its public rangeland, there can be little doubt that all interested parties are not satisfied with that direction. Indeed, a political compromise was needed to get the "pending final disposition" phrase in the preamble to the Taylor Grazing Act to assure its passage. (Clawson and Held 1957) The issue was raised again in 1946-48 when livestock and

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conservation interests clashed over a proposal to sell all grazing lands, including those in the national forests, to the permittees. The conservation interests were so strongly represented that not a single bill proposing the transfer was introduced in Congress.

The Federal Land Policy and Management Act of 1976 has led to the current effort to get the federal land transferred to state or private interests. Less emphasis is now placed on the direct transfer to private use than was the case in the 1946-48 clash. Also, a more legalistic, rather than emotional, approach is being used. Much remains to be done to determine the economic impacts and long-run consequences if large-scale transfers by sale or grant were to occur.

Wantrup proposed that "public ownership of natural resources becomes an issue under conditions which create doubt as to the superiority of public ownership as a means to increase community welfare." He also proposed two criteria by which to measure the superiority of public ownership: "social benefit" and "conservation". (Ciriacy-Wantrup 1957) Since range resources yield several products jointly, such as water, soil protection, and recreational benefits along with livestock, society receives benefits beyond those which come from livestock products. The production of these benefits is important, but so is their distribution, which is much wider under public ownership in this nation where the tradition of free hunting and fishing is strong--a point brought against the "Sagebrush Rebellion". No doubt there are some rangelands that have little to offer in terms of outdoor recreation, and on "social-benefit" criterion, should be in private hands. Conversely, there are large blocks of land in private hands that would yield large social benefits if publicly held for critical winter game ranges--including some city lots along the Wasatch Front. Similar examples could be cited for water and/or soil protection.

Wantrup's second criterion, "conservation", indicates that public ownership is an issue when some "minimum standard of range conservation is not adopted under private ownership...through education, land-use regulations, zoning, subsidies, and other policy tools" and leaves public ownership the "safest and most economical way to guarantee a minimum standard of range conservation". High mountain watersheds and some of the "occasional acres" of the plains may be illustrative of such lands. If one assumes that the criteria of "social benefit" and "conservation" are sufficiently met to warrant public ownership for multiple use management, then consideration for both market and extra-market products needs to be accounted for.

Market vs. Non-Market

Huffman points out that there is "...great variation in the terminology used to distinguish between the benefits from resource development, which can be measured in monetary terms, and those benefits to which the dollar sign cannot be applied". (Huffman 1953) Difficulties arise with the use of "tangible" and "intangible", "markets" and "extramarket", and "market" and "non-market". The greatest problem seems to come from a philosophical "hangup" as indicated in the following statements from a recent National Research Council: (1) "There is reason to be both optimistic and cautious about the state of the art in valuation of nonmarket outputs;" and (2) "A near consensus exists in the literature that the willingness-to-pay procedure is the most appropriate conceptual framework available for valuation of nonmarket outputs." (National Research Council 1981) Both statements use the phrase "valuation of nonmarket outputs" which seems to say that that which is not in market can nevertheless be valued there. One wonders if we've forgotten the lesson of the fable of the "Midas Touch" (and I don't mean auto repairs). The idea of valuing (pricing) nonmarket goods seems somewhat incongruous; but then, don't most economists know the meaning of "valueless" while denying the existence of the "priceless". Isn't there a whole field of choices (economics) where dollar signs never come into play? The truly nonmarket goods and services such as "aesthetics, endangered species, and Indian funeral grounds" cannot be expressed in monetary terms, but does that make them any less important than those which can? (Ibid.) Many things must be included in decision making that defy being placed in monetary terms. How to do it is the problem. Perhaps what we need most is a common vocabulary that can be used by ranchers, land managers, economists, and biological scientists.

Comparisons of returns from various market products produced on rangeland can be handled within the relatively well established economic theory. To the extent that some "market valuation" of "nonmarket" goods can be made, these too can be handled. It is only with the truly "nonmarket" products that the greatest difficulty arises.

In some favorable cases, the production of market goods is complementary to nonmarket goods and vice versa; e.g., deer and cattle whose eating habits complement the production of forage prefered by the other. Also, conservation measures often produce both market and nonmarket outputs simultaneously.

Ecology and Conservation

While it may have been true a few decades ago that we didn't know enough about the range to properly manage it, more and more technical information on its ecology and conservation are becoming available. One of the major errors of the past may have stemmed from the failure to recognize that the range is a "biological resource" that exhibits some characteristics of both a flow and a fund resource: a fund of soil producing a fund of plants to produce a flow of livestock feed over time or a stock of feeds to be used up. Early users saw range forage as a fugitive resource to be captured before someone else did (both the flow and the fund aspects).

Even under private use, consciously or unconsciously, the fund aspect was, and is often depleted during drought or dismal economic times. These decreases in the fund (stock) of range plants may be accompanied by or followed by a decrease in the fund aspects of the soil itself. While levels of range productivity are increasingly man-made, decisions on how much productivity is to vary over time and around what level, need to be made. Are range users economic woes to be solved or their estates created at the expense of future productivity? A nation that worries about passing the national debt onto the next generation, when the payment will also be made to members of that next generation, should truly be alarmed at passing a depleted soil and range base onto the next generation when previous generations have used up the fund aspects.

The problems of ecology and conservation vary from range-type to range-type; e.g., plains and foothills, mountains and wilderness, prairie to desert Each type will have to be delineated if management is to be effective in the various climates and locations. Indefinite range rights, changing fees, and insecure tenure have all been very detrimental to range conservation in the past. Now we have "high" interest rates that so severely reduce the value of future benefits and returns that current exploitation is almost mandated.

Management Levels

The management of rangeland has gone, or is going, through three non-mutually exclusive types: overseeing, controlling and maximizing. As we move more into the maximizing phase, much greater attention must be paid to the premise that the "condition, or quality, of our environment may itself be considered a stock resource." (Brewer 1968) To maximize short-run outputs or profits, at the expense of the long-run aspects by using up the stock resources, may well continue the deterioration of the range resource and lead to the same type short-run situation that exists in American business where long-run capital has been depleted, or not built up, while MBA graduates have shown short-run profits for the firm.

Assuming that a management plan can avoid further disaster with respect to the fund aspect of the range, a set of workable goals for the other aspects needs to be chosen. These will have to be worked out within the political powers of the groups interested in the range output capabilities.

Alston listed the following four steps as being essential for decision makers to arrive at a correct choice among alternatives, especially in a multiple-use setting:

First.--The problem must be clearly identified and all the issues properly defined. Unless a problem is understood, it cannot be solved.

Second.--The objectives or goals that are to be served must be identified specifically. Often, these are extremely vague. Goals may be single or multiple, simple, or complex.

Third.--Once the problem and the goals to be served are clearly identified, alternative courses of action must be set forth and analyzed. Rarely is there only one way to deal with a given problem. The probable consequences of each of a number of possible alternatives must be estimated.

Fourth.--The alternatives must be appraised and the decision made. The choice of any one alternative or combination of alternatives rests on the evaluation of probable consequences. This step may, and perhaps should, include a reevaluation of the goals themselves. (Alston, Op. Cit.)

A possible fifth, implicit in Alston's third, is an assessment of resources that can be brought to bear to reach the various goals according to the weight assigned to each. This becomes particularly critical when nonmarket products are goals, but require resources with market opportunity costs to produce them. What is to be maximized becomes the crucial question. Not only what is to be maximized is important, but for what reasons and for whom it is intended.

Distribution of Range Output

Implicit in goal setting is some idea of who is to receive what, i.e., how will the output be distributed. With ownership still being an issue, albeit generally assumed to remain in federal hands, one might suppose that the returns from the range products would go to all the people of the nation. This implies that all the people, via the federal government, are the typical landlord, of the storied landlord-tenant relationship. Thus far, the history of range leasing hasn't followed the typical pattern. Adminstrative level fees have left much of the returns with the permittees. (Infanger 1964) That the value of the forage was being capitalized into commensurate property has been largely overlooked when a number of comparative costs studies were made. Moreover, since the federal leases were not evenly distributed among ranchers, those who could not get a "low" fee federal lease maintained that they were at a disadvantage when having to pay higher private fees for grazing. The unevenness of this distribution may vary from place to place but as late as 1960 in the Northern Great Plains, 51.6 percent of the total operators got only 9.6 percent of the allowable AUM's while the largest, 9.6 percent, of the total operators got 49.7 percent. One must question that location and proximity to federal land could give such a distribution. With low fees this surely increased the rate of capital growth for the larger ranchers. Ranchers both large and small who originally received low fee permits were the recipients of a windfall of wealth creation at the expense of the nation as a whole. (Gardner 1966) Only in cases where the original owner-permittees still hold the land would an increase in fees come from those who received the

windfall. In all other cases, it would come from those who had paid the capitalized value of the low fee permits to previous owners.

As ranches have grown larger through the years by buying up smaller units, some of the disparity in range permit distribution may have been disappearing. Also, as fees increase, some of the larger permittees are suffering the largest wealth losses. Even though the among-rancher distribution may be being resolved, the problem of moving wealth out of local areas to the general treasury is being increased. So long as the local ranchers were able to keep fees low, the returns to the range remained with them and in the local economies. With fees rising, local areas are being impoverished by sending the fees to an absentee landlord (all the people via the government). One asks, "Why should the nation choose to take a capital payment from some local regions and not others?" Range fees are an insignificant part of the federal budget, but may be a large part of local income. Perhaps this is a point for state or private ownership of rangeland if no suitable way to compensate the local economies can be found with national ownership. In lieu, tax payments scarcely appear adequate.

No doubt the federal management units located in local areas do add to these areas' economies. Also, as range improvements begin, new questions of how ecological conditions can be restored and the benefits distributed among users will have to be resolved. New possibilities for greater outputs of recreation and livestock can both be generated from such improvements. Both technical and socio-economic research will be needed to give guidance to decision-makers.

Objectivity in Socio-Economic Research

The issue of objectivity is not specific to range economics research. It deserves attention here because of the multitude of groups with interests in range products. Perhaps research can never be completely devoid of value judgment, but according to Popper, "scientific objectivity consists of the freedom and responsibility of the researcher (1) to pose refutable hypotheses,(2) to test these hypotheses with relevant evidence, and (3) to state the results in an unambiguous fashion accessible to any interested person". (Castle 1968) This method is an impersonal one that permits scientists to replicate one another's work and reach the same conclusions. If it can be assumed that objectivity is in the public interest, then threats to objectivity need to be curtailed or prevented.

Castle listed five major threats that need to be guarded against: (1) the researchers desire for approval, (2) advocacy of a particular public policy, (3) vested interest in a particular theory, hypothesis, or approach, (4) desire to avoid controversial problems, and (5) desire for personal financial gain. (Ibid.) Any one of these threats may bring less than the returns society should expect of the social investment it makes in research. Moreover, those who allocate funds may bias research efforts by funding only those they expect to support their particular public policy views. This can happen in biological-technical as well as in socio-economic research.

RESEARCH PRIORITIES

Range research must compete for funds available for all research, especially for those allocated for food output enhancement in agriculture and environmental quality control. Assuming that society will continue to make a social investment in range research, what priorities can be suggested to assure that the greatest returns from the investment can be achieved? (As in the case of input-output, this becomes doubly difficult when resources that are committed have opportunity costs in the market, but the results of research may suggest greater emphasis on nonmarket products.)

Biological-Technical Data for Management Decisions

If we are correct in assuming that public ranges are to be managed for maximum returns--in whatever terms--to society, then a first priority would appear to be a determination of which types of bio-technical data would be most valuable to the managers. (Not an easy task.)

The output of research (new knowledge) is valued as an investment by society because it will enhance goal attainment. (Paulsen, Kaldor, 1968) The more important the goal, the more valuable is new knowledge to reach it. It will take the best tools that economists have, used in the most effective ways, to help guide the research investment procedure. But work with technical scientists, economists must, if limited available research resources are going to produce the greatest returns.

A group of range scientists recently identified five categories of new or unsolved problems needing research. "Ranked by priority, the five are: (1) dynamics of individual plants and plant communities; (2) identification, classification, and inventory of range ecosystems; (3) improvement of rangelands for increased productivity and stability; (4) short- and long-term grazing impacts; and (5) influence of economic, social, and political constraints on management of range resources". (Klemmedson 1978)

As an economist, one may question why economics is at the bottom of the list; yet, it is recognized that much economic analysis depends upon technical coefficients. The task is to work with the technologists early in the design stage of experiments to assure that the data generated will permit economic analysis useful to management. With research funds restricted or reduced, it becomes all the more important that those funds available be used where the greatest returns can be expected in the shortest time frame. This surely does not

mean that long-term basic research would be abandoned because some of it is mandatory to understand range dynamics, but what and how much would be based on the expected usefulness of results for decision making. This would mean that a host of projects dealing with inputs and outputs from either structural (fencing, irrigation, water development) or non-structural (revegetation, fertilization, burning, poisonous plant control, clearing, plowing, grazing intensity, etc.) improvements would be planned and carried out to yield data for management. (USDA Forest Service 1979)

Also, since rangelands produce more than forage, range research planning must include consideration for energy, recreation, minerals, wildlife, water, and how all are interrelated. Saunderson suggests that, "The watershed value of western range and forest lands often is so overwhelming as to dwarf the value of rangelands for forage yield or for short-run livestock production". (Saunderson 1975) Output competition also comes from sheep vs. cattle, livestock vs. game animals, and recreation vs. watersheds. All require physical and economic consideration. The economic framework to treat many of these problems is available when the technical coefficients can be developed.

As expressed earlier, there is a whole field of range policy research which stems from the issues of ownership, distribution of benefits, and conservation. These issues give the economic and management sciences a noble challenge to make a contribution to the maximizing of the benefits and outputs of the immense range resource. Small changes in the output of forage and/or other products per acre of range can add up to very large increases in total output over the vast western range. Efficiency of resource use requires that the effort be made to bring these increases about in cost effective ways.

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CLEARING-UP THE TECHNOLOGICAL GAP IN RANGE MANAGEMENT

John R. Lacey

ABSTRACT: Many ranchers on the Western rangelands are not using recommended range improvement practices even though results from research studies and economic analyses indicate that the improvements are profitable. This general situation is described as a technological gap. The purpose of this paper is to discuss reasons why the gap exists, and to suggest an approach that can be used to resolve the gap.

INTRODUCTION AND PURPOSE

The primary goal of this symposium was to accelerate the application of good management practices on rangelands. The importance of economics in this resource-oriented goal has been emphasized repeatedly, but now it is time to examine the human factor.

It is the range manager who makes the decisions regarding what happens on the range. The quality of his decisions depends on how well informed he was at the time the decision was made. Informed decisions require that all options and alternatives be known. The educational process necessary to implement good range management practices is referred to as technology transfer.

Educational programs in range management originated around 1950 with A.H. Walker, Ray Johnson, Karl Parker, and other early Extension Range Specialists. Their efforts followed the philosophy outlined by W.R. Chapline (Chief of Division of Range Research, U.S. Forest Service) in 1936 when he said, Extension seeks . . . . "to spread applicable knowledge of range management among the owners, users, and managers of range lands and to demonstrate and interpret desirable range-use practices adopted to local conditions in order that range lands may perform their fullest potential services, both economic and social ...." Although much progress has been made in some areas, it seems that a quality effort has not been maintained in other areas. For example, Wight (1973) and Lacey (1981) believe that many range managers do not use improvement practices even though results from research studies and economic analyses indicate that the improvements are profitable. This general situation suggests that our educational effort in the area of range economics is characterized by a technological gap. The purpose of this paper is to suggest how this technological gap in range management can be resolved. Before a solution can be proposed, it will be logical to review published data that verify the technological gap, and to discuss the factors that may be disrupting the educational flow of economic information.

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RESULTS AND DISCUSSION

The Gap Exists

Biologists in the northern Great Plains have repeatedly measured biological benefits from seeding crested wheatgrass (Agropyron cristatum), Russian wildrye (Elymus junceus), and other seeded species (Lodge and others 1972; Houston and Urick 1972; Black and Reitz 1969; Smoliak 1968; and Smoliak and Slen 1974). In addition, range economists have verified the economic value of seeding these species (Godfrey and others 1979; Kearl and Cordingly 1975; Gray and Springfield 1962), and Extension Specialists (Parker 1961) have advocated their use. Although it seems that an educational package of this nature would be convincing, 70% of the ranchers in eastern Montana do not have any seeded pastures (Lacey 1981). The fact that the U.S. Forest Service has invested over 99% of all range improvement money on additional water; fences, and other structural kinds of improvements in this area (Horvath and others 1978) suggests that other range managers are also skeptical about seeding tame species. Thus, evidence suggests that range managers in the northern Great Plains are not readily adopting a recommended improvement practice.

Another example of the technological gap is the cattle breeding program in southcentral New Mexico (or lack of one), where less than 2% of the ranchers grazing Public Land have implemented a seasonal breeding program (U.S. Department of Interior 1979). This attitude certainly ignores the recommendations that are preached in beef production textbooks (O'Mary and Dyer 1978). Other examples of range managers not using recommended practices can be found throughout the western ranges. In fact, a recent report (National Cattlemen's Association 1982) found that cattlemen could effectively increase red meat production 5-20% through genetic improvement, 10-30% through a good range management program, and forage production efficiency from 20-50% by using known range improvement techniques.

A technological gap restricts production by preventing the manager from making the best possible use of the range resource. Thus, a more technically efficient operation would be able to produce more output at each level of input (figure 1). Profit is expected to increase when the new technology is adopted.

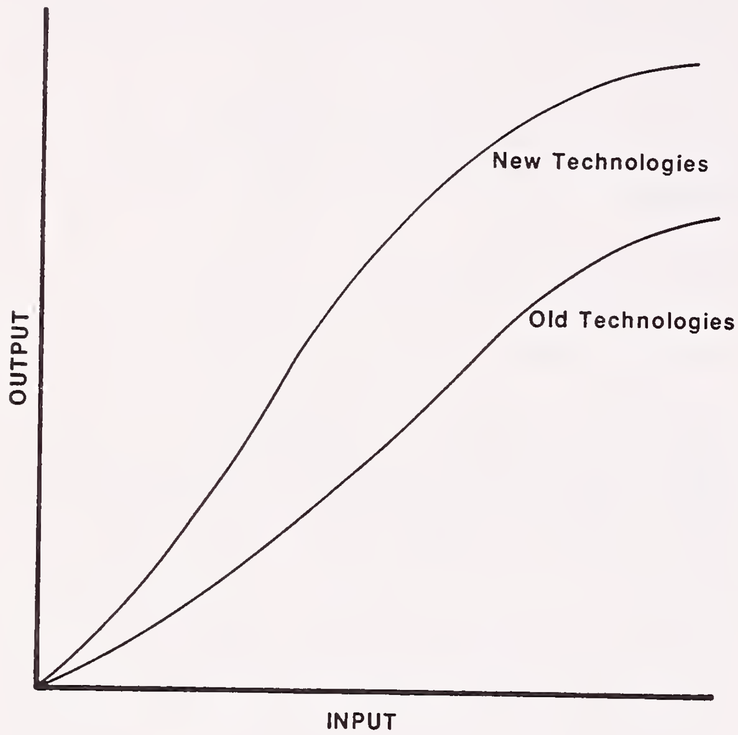

Figure 1. The level of output from a given set of input increases with new technology.

Reasons for the gap

There are at least five major explanations why land managers have not adopted recommended practices. They include: 1. faulty economic models, 2. cash flow problems on the ranch, 3. resistance to change, 4. over-optimistic research, 5. failure of the Extension Service. Because of their diversity and complexity, each will have to be discussed separately.

Faulty economic models.--James Gray pointed out in the opening session of this symposium that a tremendous resource base of range economic information has been compiled. Furthermore, this base has been significantly expanded by some of the other papers presented during this symposium. Although this logic suggests that range managers should not be suffering from the lack of technical economic information, other evidence suggests that range economics is not fully understood.

A major criticism is contained in Martin's (1972) comment regarding the Regional Research Project W-16, the "Economics of Rangeland Improvement." W-16 was activated in 1953 and aimed:

> to facilitate orderly development and conservation of the present or potential rangelands of the western region by economic evaluation of the costs and returns from range vegetation on rehabilitation and closely associated practices.

He felt that the project showed that "a lot of people put in a lot of time trying to understand the economics of range improvement investment. They were relatively unsuccessful in their efforts not because of a lack of economic sophistication, but because the response data relative to improvement practices were almost totally lacking."

It is conceivable that recommendations based on recent linear programming (LP) analyses are subjected to similar limitations. Not only do they incorporate the same biological data, but the relationships are expressed in a linear fashion. This may explain why most LP studies consistently conclude that the net income of typical ranches can be significantly increased by implementing range improvement practices and/or by switching from cow-calf to yearling operations (Lacey 1981; Hewlett and Workman 1978; Capps 1981; Leistritz and Qualey 1975). Although these conclusions may someday be verified, economists should remember that "modeling was never intended to function as a means to scientific knowledge" (Romesburg 1981). In other words, a serious credibility gap may develop if model-based recommendations are implemented by working range managers.

Cash flow problems.--Livestock producers have been and are in a period of difficult and uncertain times. This can be verified by addressing two important financial questions about a ranching operation. First, will the ranch produce sufficient net income for the ranch family to live on after all operating expenses (including loan service) have been paid? Second, how much net ranch income (including real estate appreciation) is available to compensate investment of owned capital (equity)?

These questions can be be answered by analyzing ranch income with the modified income statement developed by Workman (1981). Fortunately, a small and large Utah cattle ranch were recently analyzed (Capps and Workman 1982) and these data should be representative of many Great Basin ranching operations.

Capps and Workman (1982) found that the small and large ranches earned a negative net return of \$14,769 and \$28,347, respectively, for family living expenses (table 1). However, after considering the mortgage principal payment and land appreciation, the ranches did receive a 3 and 2% respectively, return on owned ranch capital. This is a much lower rate than what investments in other alternatives normally receive. From a rancher's standpoint, any money for range improvements must be taken from the amount available for family living, or borrowed. Thus, it is apparent that many ranchers are caught in an economic squeeze and cannot afford to invest in any additional range improvement practices.

Table I. Modified Income Statement for Typical Composite Ranches, Utah, 1977 (Taken from Capps and Workman 1982)

ITEMS	SMALL RANCH	LARGE RANCH
Annual Cash Returns	18,361	38,944
Minus Annual Cash Cost	18,269	42,064
Minus Depreciation	4,244	10,962
Net Ranch Income	-4,152	-14,082
Minus Debt Service Cost	10,617	14,265
Net Return Available for family living expenses	-14,769	-28,347
Land appreciation	30,370	45,842
Mortgage Principal Payment	4,945	6,152
Gross Proceeds to Ranch Investment	20,546	23,647
Minus Family Labor & Management	10,000	10,000
Net Proceeds to Owned Ranch Capital	10,546	13,647
Percent Return on Owned Ranch Capital	3.13%	2.18%

Resistance to change.--A recent report by the National Cattlemen's Association (1982) found that "many cattlemen probably feel that they are operating as efficiently now as they can, but the committee's study showed that most actually are not." Furthermore, "the successful cattlemen will be innovators, willing to change and to adopt new production and marketing and business management techniques." Their optimism for change may come true because "adverse conditions are forcing more positive changes in the beef industry than all the teaching and preaching ever have" (Drover's Journal 1982).

Perhaps the cattlemen are capable of adjusting to rapid changes during the 1980's. However, Shneour (1981) reports that it often takes from 20 to 25 years before an innovative idea is readily accepted for use. His examples included the heart pacemaker which was invented in 1928 and first used in 1960, and the bicycle which was invented in 1862 and wasn't refined until 1937.

This lag period between an idea and it's adoption may have serious ramifications in our effort to implement range management practices. Range studies were not initiated until about 1900, and the Society of Range Management was not founded until 1948. Thus, range management is so new that some of the range economic principles may be ahead of their time.

Failure of the Extension Service.--Jack Artz (1982) recently discussed the progress that Extension programs in range management have made. Substantial gains were made in the areas of 1. teaching the general public about range management, 2. incorporating sound range management practices into government policy and programs, and 3. promoting programs to improve productivity and encourage sound management of private rangelands. Although this success explains why the Cooperative Extension Service (CES) is the envy of education systems worldwide, it may be possible to improve the Extension range management programs.

Some areas in which the CES could improve were discussed by Artz at a U.S./Mexico Range Management workshop (1981). He felt that we were not training people for technology transfer systems. In addition, he recognized that the Extension Service could never do the job alone, instead it should be the catalyst for technology transfer. Information must also be transferred by researchers, ranchers, and technicians. He also felt the system could be improved if information specialists and producers were full partners in policy and research planning and development.

Each of his concerns needs to be corrected within Montana's Extension Service. For example, our system does not reward researchers for their Extension work. Extension range personnel also have very little input into range research planning by the range faculty within the Animal and Range Science Department. Hopefully, many of these deficiencies will be corrected by more interaction between research and Extension personnel.

Artz's concern about Extension personnel being ill-trained in range management is substantiated in Montana, where no one can question the importance of the range resource. It covers 70% of the state, and provides most of the forage for a livestock industry, whose cash receipts total over $800 million annually. Unfortunately, only two individuals (State Extension Range Specialist and one County Agent) within Montana's Extension Service have a degree in Range Management. Instead, the agricultural county agent positions are dominated by individuals with degrees in Agricultural Education and Animal Science (table 2).

Table 2. Major areas of study by Montana County Agricultural Agents.

	Number of Individuals			
College Major	BS	Both BS & MS in field	Only MS in field (BS in other field)	Total
Agricultural Education	10	5	5*	20
Animal Science	8	8	2	18
Crops & Soils	6	1	1	8
Agricultural Econ. or Business	4	1	0	5
Misc.	0	3	0	3
	28	18	8	54

*The county agent that earned a BS degree in Range Management went on to earn a MS in Agricultural Education.

This failure to recruit range managers into the system threatens to erode the strong rapport that has been built with the producers. Producers are becoming skeptical of advisors that: 1. bring an experiment station, rather than a ranch management program to the ranch, 2. place too little value on the rancher input, and 3. do not understand the jobs or skills required in a sound ranch operation. Some producers are also losing their motivation to study range management when: 1. agencies advising them come up with several conflicting ideas, or 2. recommended improvements only assist the general environment without returning a profit to the ranch. The best way to eliminate these criticisms of the CES is to hire more personnel with range management training. Agents with this training would have the interest and knowledge to assist with range demonstration plots and would enhance inter-agency cooperation.

Over-optimistic research.--Results from some research efforts may be unintentionally inflated. This possibility exists because our American lifestyle is oriented toward success, rather than failure. Thus, in a researcher's drive to "publish or perish" he may be more inclined to undertake the tedious task of preparing an old data file containing favorable, rather than unfavorable, herbage response data for publication. He is aware that success stories from implementing range management practices are far more numerous (in our scientific and ranch magazines) than are the failures. Thus, the published range improvement information is biased-upward to the extent that our system favors success over failure.

Research is commonly conducted on small plots for economy and to decrease the possibility of environmental noise (thus increasing the possibility of uniform results). However, range managers do not have the luxury of using small plots. Instead, they must usually take the management recommendations based on small plot data, and apply it to large acreages. Any range manager who has seeded a pasture, burned sagebrush, or used a herbicide to control a noxious plant, knows that his management efforts will not result in a uniform herbage response across the treated area. Thus, from a management standpoint, the published data may be biased-upward.

Solution to the gap

It is unrealistic to single out any one of the five possible explanations as the primary culprit responsible for the gap. Instead, it is more practical to blame all five factors. This suggests that the solution is increasingly complex. However, by reviewing the various steps of the educational process, a logical solution can be derived.

Steps of the educational process.--The CES is the largest system of informed continuing education in the world. It's Extension education programs are successful because local people are directly involved in developing, executing and evaluating the programs (Hutchison 1975). However, manpower and funding make it impossible for the CES to do the job alone. Thus, the CES should be coordinating the educational effort among other agencies. This effort needs coordinating because other federal agencies do employ many Range Conservationists in Montana:

Number of Range Conservationists Employed (Aug. 1982)

Agency	Permanent
SCS	10
BLM	81
USFS	105*

*51 actually classified as Range Technicians.

Even though some of these conservationists may not have a four year degree in range, the numbers are very impressive in comparison to the number of range trained personnel within Montana's Extension Service.

All range managers should be regarded as teachers, or conveyors of systematized knowledge. Thus, each must understand how range management information can be transferred in a form that is acceptable to the learners. This problem is compounded because there are many kinds of learners (youth, adult, private land owner, land manager, etc.), each with his own motivation, resource capability, and level of knowledge. Therefore, rather than trying to develop a single-answer approach in education programs, a specific approach is needed to address each specific situation (Ramsey and Shult 1981).

The problem of transferring range economic information can be simplified by targeting an adult audience. Adult curricula should be built around real-life problems of adults in society rather than around an academic organization of knowledge (Ramsey and Shult 1981). Therefore, education methodology of youth should not be used as a model for adult education. Adults enter into a learning experience with more and different kinds of experience than youth, and are ready for more different types of learning. These adults who are interested in further training have three major learning traits. First, they want to move ahead in meaningful areas. Second, adult learners want to build upon what they already know. Third, they have many responsibilities to work, families, and etc... Thus, adult teaching must be problem centered, the current level of student's knowledge must be known, and the learning situations must be scheduled at convenient places and times.

After a specific audience is selected, it is necessary to use the best tool to transfer the technology. Bulletins are effective if they are directed to the specific audience (Ramsey and Shult 1981). However, several studies from a wide variety of sources indicate that "the written word" may not be the best tool to implement a management practice. For example, Scandarani (1978) studied the levels of influence from different sources of information on the adoption of deferred grazing systems. Although 22 sources were available to ranchers -- personal contacts (with SCS, CES, etc) were the most important source.

"Learning by doing" or the "self-help" concept of teaching originated under the leadership of Dr. Seaman A. Knapp, U.S. Department of Agriculture educator. He established a "result demonstration" on Walter C. Porter's farm in 1903, in Texas, to show the local farmers new cropping practices designed to increase their production and eventual profits.

The farm result demonstration method was successful because it provided the means for a land holder to try new innovations with assistance of specialists in the new technology. This approach allows the landowner to do the work on his own land, and the results depend on him. In other words, as Dr. Knapp said, "what a man hears he may doubt, what a man sees he may possibly doubt, but what he does himself he cannot doubt."

Success hinges on the landholder. The specialist/educator must select a key individual in the community. One who is motivated and well perceived by his peers. A highly successful result demonstration with a rancher who has no credibility will not produce any positive spin-off.

Once a cooperator is selected, the specialist/educator should only act as an advisor. The cooperator should set objectives, make decisions, do the work, and measure results. This ensures his awareness of all contraints and problems. Thus, this situation directly contrasts with the agency-established demonstration plots that lack credibility. Agencies do not make decisions in the same context as an individual rancher.

A logical solution.--Winston Churchill's message that those who fail to study history will have to live it over is directly applicable to our problem. Obviously, more range managers must be involved with technology transfer and their tools must be developed to allow the adult to learn while doing. These are the reasons why the coordinated effort by producers, Extension, and research have been extremely successful in the Integrated Pest Management (IPM) program. Most evidence suggests that a similar program would be the best tool for addressing the technological gap in range management.

Demonstration ranches, not plots, are needed because it is necessary to analyze the entire ranching operation. For example, the dollar values of herbage increases resulting from improvement practices are much greater if they alleviate a bottleneck in the operation, rather than provide a surplus of forage during the peak of the summer growing season (Workman 1980; and Kearl 1975).

Result demonstration ranches are not a new idea. Ralphs and Busby (1978) used the approach to: 1. demonstrate and document the environmental and economic impacts of range and livestock developments on a total ranch operation, 2. involve the federal and state land management agencies with the rancher in a coordinated planning and implementation effort, 3. use the ranch as a showcase to motivate other ranchers, users, and agency administrators to support and implement range improvements, and 4. involve participation by the agricultural lenders. An added feature of this approach is the Coordinated Resource Management and Planning (CRMP) Act that dictates cooperation among the USFS, BLM, SCS, and the CES.

Funding is a serious problem for large-scale demonstration ranches. However, the 1982 Farm Bill did authorize money for a cooperative demonstration effort in range management between researchers, producers, and the Extension Service. Appropriation of funds for such an effort is the one specific goal that each of us should strive toward. This type of approach would allow herbage

response data to be quantified in economic terms. Multi-disciplinary interaction on demonstration ranches will insure that the range manager, economist, and specialist fully understand all options and alternatives. At that point, the question of the technological gap would be resolved and good range management practices implemented. Until then, this symposium cannot be termed a complete success.

CONCLUSION

This paper accomplished three things. First, it used published literature to verify the existence of a technological gap -- or an area where range economic information is not being transferred to the range manager. Second, it discussed how faulty economic models, cash flow problems, resistance to change, over-optimistic research, and failure of the Cooperative Extension Service all contribute to the gap. Third, it proposed a solution to resolve the gap.

The proposed solution hinges on an effective educational effort in range economics. While it is logical to expect the CES to take a lead role in this effort because its mission is to bring practical knowledge to the people, it is illogical to expect them to do it all. Instead, a cooperative inter-agency effort involving producers, researchers, Extension personnel, and demonstration ranches (patterned after the Integrated Pest Management Program) is the primary tool that needs to be used to facilitate this transfer of range economic information. There is no reason why range management decisions should be made without full knowledge of all available alternatives.

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Contains 22 papers presented at the first formal meeting of researchers and others involved in range economics since the late 1960's. Topics include the history of range economics research, critiques of recent economic evaluations, proposals of new techniques, and technology transfer.

KEYWORDS: economic evaluation, externalities, range valuation, range econometrics, range policy

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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